Mekelle University

College of Social Sciences and Languages

Department of Geography and Environmental Studies

Post Graduate Study Program

GIS and RS Based Assessment of Area Exclosure and Vegetation Cover Change in KoraroTabia, HawzenWoreda

BY: Araya Kiros

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Geography and Environmental Studies: Specialization in GIS and RS

Major Advisor: Biadglign Demissie (Asst. Prof.)
Co-Advisor: Hailemariam Meaza (MSc.)

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Declaration

This is to certify that this thesis entitled "GIS and RS based assessment of Area exclosure and vegetation cover change in KoraroTabia, HawzenWoreda" submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in Geography and Environmental Studies with specialization in **GIS and RS** during the year of 2014 at Mekelle University, Mekelle, Department of Geography and Environmental Studies done by Araya Kiros under my supervisors of Biadglign Demissie(Ass. prof.) and Hailemariam Meaza (MSc.). I further declare that this thesis is my original work and has not been submitted to any other University or Institution for the award of any degree or diploma and that all sources of materials used for the thesis have been duly acknowledged.

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Abbreviations and Acronyms

Aexp	Agricultural experts
AVHRR	Advanced Very High Resolution Radiometer
DEM	Digital Elevation Model
GOs	Governmental organizations
GPS	Global Positioning System
Ha	Hectare
HHds	Households
LULC	Land use and land cover
M.V.P	Millennium village project
NDVI	Normalized Difference Vegetation Index
NGOs	Nongovernmental organizations
NIR	Near-infrared radiation
RS and GIS	Remote sensing and Geographic information system
TIRS	Thermal infrared sensor
TM	Thematic Map per
TNRS	Tigray National Regional State
VIS	Visible radiation
WFP	World Food Program

Abstract

Land degradation has been a major environmental problem in northern highlands of Ethiopia. Consequently, the degraded landscapes were poor to offer landscape services for the society. As part of the government responses, area exclosure has been implemented to halt land degradation and improve the sustainability of environmental resources in Tigray. Thus, the current study was conducted to assess the area exclosure and vegetation cover change and its impacts on the community in Koraro, eastern Tigray. The application of remote sensing, geographical information system and satellites imageries; Landsat4-5 TM (1984, 1995, 2000 and 2010) and land sat 8 (2014) were used to analyze land use and land cover dynamics and vegetation cover change. NDVI was considered to detect the vegetation cover change in the study area. Focus group discussion, interview and structured questionnaire were also used to investigate impacts of area exclosure on the livelihood of the farmers. The major land use land cover types in the study area were identified as farmlands, settlements, vegetated area and bare lands. The land use land cover types in Koraro have changed in the last 30 years. The NDVI value shows an increasing trend due to the introduction of area exclosure. In this regard, the NDVI value for 1984 and 2014 are 0.140 and 0.20 respectively. Moreover, the study shows that area exclosure has positive response to the availability of fodder, firewood and farmland productivity. This indicates that livelihood of the community is partly improved due to the presence of area exclosure. However, some of the respondents were resistant for further expansion and implementation of area exclosure, indicating further work is needed to convince them. All in all, this study confirms that area exclosure is an important rehabilitation tool to restore the degraded landscape and thereby improve the lives of the poor farmers. This indicates that the expansion of area exclosure to the rest degraded areas is an important option to bring back our wastelands into economically active land. Therefore, area exclosure should be expanded to other areas where soil erosion and forest degradation persists by considering the socio-economic of the local communities.

Key terms: *Land degradation, area exclosure, land use, vegetation cover, NDVI, livelihood*

CHAPTER ONE

1. Introduction

1.1 Background of the Study

Land is the major natural resource that economic, social, infrastructure and other human activities are undertaken on. Land is a fundamental factor of production and through much of the course of human history. It has special place for the people of dry lands of the world, where their livelihood is entirely dependent on their environment and the livelihood strategies are limited (Ahmadi et al., 2010).

However, land degradation which includes degradation of vegetation cover, soil degradation and nutrient depletion, is a growing ecological problem in Tigray, Northern Ethiopia (Nyssen et al., 2009). The growing populations, an increasing demand for cultivated land and increasing socio-economic necessities have created pressure on the land resources. This pressure has resulted in unplanned and uncontrolled changes in land use and land cover in the region. Changes in land use have occurred at all times in the past, presently ongoing, and are likely continuing in the future (Lambin *et al.*, 2003). Similarly, other study shows that rapidly growing human population, extension of arable land and similar human and natural factors have become the main factors causing desertification, deforestation and degradation of soil and for ecological and environmental changes (Degelo, 1996).

The clearing of forest land for agricultural use, the cutting of trees for fuel, and construction materials, and agricultural implements, the burning of bushes and woodlands, and overgrazing have led to the loss of forest cover at an alarming rate. Consequently, the biodiversity has been threatened. Besides to this, it is common that severe shortages of fuel wood have rendered rural communities increasingly dependent on animal dung for fuel, which would have increasing fertility, contributing to the problem of soil erosion and as a result declining of agricultural productivity (Girma, 2001).

Following the long history of land degradation, many land rehabilitation and conservation programs have been carried out in northern Ethiopia. A historical vegetation cover change study by Nyssen et al., 2009) indicates that the vegetation cover in northern Ethiopia has improved during the last century through land rehabilitation programs. Part of this, community woodlots and household tree plantations have also contributed to the improvement of the vegetation cover in northern Ethiopia (Jagger and Pender 2003).

Rehabilitation of degraded lands through closed areas has been promoted by regional authorities since 1991 in Tigray. The major objective behind establishing exclosure areas is to bring to an end and reverse land degradation to check the adverse effects of runoff improve the microclimate and create conducive environment for humans and livestock by maintaining environmental stability. It is a method for land recovery and re-vegetation by protecting the area from human and animal interference for period of time in the given area (Bendz, 1986). According to the same author, in closed areas; it is generally believed that the land resources such as soil, wild flora and fauna, or water could be protected from degradation.

Recently, establishment of area exclosures to tackle the problem of land degradation has been practiced in the central and highlands of Ethiopia and is considered advantageous since it is a quick, cheap and easy method for the rehabilitation of degraded lands (Bendz, 1986). Exclosure is an assisted natural regeneration strategy to restore degraded forests by protecting areas from livestock intervention (Parrotta et al. 1997). Studies have indicated that vegetation recovery in the exclosures is quick, particularly in the younger stages (Mengistu et al., 2005; Abebe et al., 2006).

Although there are relatively many studies in the country which provide a measure of success or failure of area exclosures as one strategy to help prevent decline of soil degradation, but they cannot attribute to Tabia Koraro. Hence, there is a need to evaluate the change and trends, dynamics and type of land use and land cover changes and to project future trends in the study area and to expand such method of protecting land degradation in other Tabias in the Woreda as well as to other areas in general. Therefore, the major concern addressed here is, to assess the land use land cover of the rehabilitation area, to answer questions related to the area exclosure and vegetation cover changes and its impacts on the livelihood of the peasants in Koraro, Eastern Tigray.

1.2 Statement of the problem

The severity of soil erosion in the Tigray region and in Ethiopia in general, is the result of the mountainous and hilly topography, heavy rainfall, and low degree of vegetation cover. In addition to this due to population pressure and other anthropogenic factors, deforestation and subsequent land degradation (desertification) are observed in the northern highlands in particular. In the past 100 years only, the total area of land covered by forest in Ethiopia has declined from about 40% to an estimated area of 2.4% in 1990 (Eshetu and Hogberg, 2000).

Following to the alarming environmental degradation and the resulting poverty and poor quality of life, government and nongovernmental agencies have implemented various land rehabilitation programs. To combat these severe resource degradation problems national level environmental conservation and rehabilitation efforts were started in the1970s, with particular focus on the fast deteriorating highland areas of the country (Campbell, 1991; Hoben, 1995).

The practice of establishing exclosures on actually degraded environment has emerged as a promising practice in different parts of Ethiopia to prevent environmental degradation and combat desertification by rehabilitating vegetation (Bendz, 1986; Mitiku and Kindeya, 2001). Koraro area was the most degraded part of the regional state. Besides to this environmental challenge, the area was stroked by poverty. This cumulative environmental and economic problems attracted government, many public organizations and NGOs. Particularly, The Millennium Village project in collaboration with World Food Program, Office of Agriculture and Rural Development and local community has implemented in KoraroTabia, usually called Millennium Village.

There are many studies on different exclosure areas made before in many other areas (e.g. Haile, 2012). However, the diverse agro-ecological conditions of Tigray, past studies are not enough to conclude about the effectiveness of exclosure to reduce land degradation. Moreover, there is no systematic study conducted to assess the integrated intervention implemented by Millennium Village project in the Millennium Village on environmental resources and local people. Therefore, the study initiates to assess the area exclosure and vegetation cover change and its impact on livelihood of the local community in Koraro Tabia, Hawzen Woreda.

1.3 Objectives

1.3.1 General Objective

The general objective of this study is to assess the area exclosure and vegetation cover change in KoraroTabia, Hawzen Woreda.

1.3.2 Specific Objectives

Specific objectives of this study are to:

1) Analyze the land use and land cover change for last 30 years in the study area.
2) Analyze the changes in vegetation cover for the last 30 years.
3) Compare the vegetation coverage of watersheds with and without area exclosure.
4) Analyze the impacts of area exclosure on the livelihood of the local farmers.

1.4 Research Questions

- Is there any significant change in the land use and land cover at temporal scale?
- Is there a change in vegetation cover for the last 30 years?
- Is there any difference between the vegetation coverage of watersheds with area exclosure and without area exclosure?
- What are the impacts of the area exclosure on the livelihood of the local farmers?

1.5 Significance of the Study

The evaluation of land use and land cover change within the study area has scientific and development importance. Therefore, this study would provide base-line information on issues of land use and land cover changes and dynamics in relation to vegetation cover change in the study area for the future. This study also provides firsthand information on the spatial extent of vegetation. Basically, such information is vital for comparing the past and present conditions and predicting the future trends of the land use and land cover change and expanding such method of protecting the land from soil degradation and expanding such techniques to other Tabias in the Woreda in particular as well as to other Woreda as a model in general. Therefore, the findings from this study would primarily benefit the local community, Woreda land managers and NGOs which have implemented land resource management programs, as it evaluates their program on the well-being of land and would suggest some key issues for further redesign. Furthermore, policy-makers, development planners, local land-managers, concerned NGOs and any responsible bodies of water and soil conservation programs would be simply equipped to take appropriate decisions.

1.6 Delimitation of the Study

This study is actually a local level study and thus focuses mainly on issues of area exclosure and vegetation cover change. In spite of the land degradation and the subsequent government and non-government response is at larger scale, this study is delimited to the study of area exclosure and vegetation cover change in Tabia Koraro, in Hawzen Woreda in the Eastern zone of Tigray. Even though it is difficult to examine all areas, studying some specific area is a great importance for investigation. In order to investigate the change, this study attempted to investigate vegetation cover change in the study area. This study is delimitated to assess on the issues of land use and land cover change for the last 30 years, vegetation cover, and impact of area exclosure on the livelihood of the local farmers.

1.7 Organization of the Thesis

The content of the thesis is presented in five broad chapters. A short introduction and overview of area exclosure and vegetation cover change, statement of the problem, objectives, research questions, significance and delimitation of the study are presented in chapter one. In chapter two the literature review, about general concept of land use and land cover, the role of remote sensing and geographical information system on LULC as well as vegetation cover change are described. Chapter three deals about the general description of the study area, material and the methodologies are presented. Results and discussion, conclusion and recommendation are presented in chapter four and five respectively.

CHAPTER TWO

2. LITERATURE REVIEW

2.1 Soil Conservation Strategies in Ethiopia

Ethiopia is a country where soil degradation is prevalent at a devastating rate. The average annual rate of soil loss in the country is about 12 tons/ hectare/ year, and it can be even higher on steep slopes and on places where the vegetation cover is low. The amount of yield reduction as a result of the loss of topsoil each year is increasing substantially. This makes the issue of soil conservation not only necessary but also a vital concern if the country wants to achieve sustainable development of its agricultural sector and its economy at large (Tamirie,1995).

So as to reduce the existing problem of land degradation, Ethiopia is engaged in a massive soil and water conservation activities in many degraded parts of the highlands since the 1970s. To stop further land degradation, the government of Ethiopia has initiated a number of projects including soil and water conservation works, tree planting and the establishment of area exclosures with the financial assistance of international donors, mainly the W.F.P (Emiru, 2002). According to Hawzen office of Agricultural and rural development (2014) in the study area, there are also different international donors like M.V.P and W.F.P participated to conserve soil and water which were early degraded land.

2.1.1 Tree Planting

In hillsides where no farming is practiced, and livestock grazing is not productive are set aside for communal plantation or forested areas. Different NGOs and GOs were involved in plantation programs to tackle the problem of land degradations in many parts of the country. Many NGOs were involved in afforestation activities around the study site of Hawzen Woreda and in Tabia Koraro in 2005. For instance, there were some trees planted by World Food Program. In addition to this the Millennium village project had also involved in plantation programs in study area. In some places communal plantations or forests are being distributed among young people who do not have land to farm (Kindeya, 2004).

Increased involvement of people in forests through community based management programs has in many cases proven to benefit the environment (soil erosion reduction, water supply and biological diversity) and reducing local poverty. The formulation of forest plantations can achieve a number of needs, including; carbon fixing, the provision of a wood supply source that is an alternative to the natural forest; the restoration of degraded land and generation of income and employment (FAO, 1999). Also Maginnis and Jackson (2003) stated about tree planting to conservation of biological diversity, both at the site and landscape level, extensive reforestation with plantation species can help ameliorate long-term environmental degradation in badly eroded landscapes, restoring not only ecological functionality but also site productivity.

2.1.2 Area Exclosure

Area exclosure, which is a type of land management implemented on degraded, generally open access land, is a mechanism for environmental rehabilitation with a clear biophysical impact on degraded lands. In closed areas, it is generally believed that the land resources are protected from degradation. Area exclosure involves the protection and resting of severely degraded land to restore its productive capacity. There are two major types of area exclosures practiced in Ethiopia: (1) the most common type involves closing of an area from livestock and people so that natural regeneration of the vegetation can take place; (2) the second option comprises closing off degraded land while simultaneously implementing additional measures such as planting of seedlings, mulching and establishing water harvesting structures to enhance and speed up the regeneration process (WOCAT, 2013).

The major objective behind establishing exclosure areas is to halt and reverse land degradation to check the adverse effect of runoff, improve the micro climate and create conducive atmosphere for humans and livestock by maintaining environmental stability in the trees, shrubs, herbs and grasses (REST,1995). Area exclosure is the most crucial method of rehabilitating lands through human innervations and natural regeneration. It is a method for land reclamation and re vegetation by protecting the area from human and animals interference for limited period of time depending on the re vegetation capacity of the area.

2.2. Land Use and Land Cover Change

The increasing population and socio-economic requirements create demand on land use and land cover for different activities. This pressure results in unexpected and uncontrolled changes in land use land cover (Seto, 2002). The LULC changes are generally caused by misadministration of agricultural, and forest lands which lead to severe environmental problems such as landslides, floods, environmental degradations etc.

Every plot of land on the earth’s surface is unique in the cover it possesses. LULC are different yet closely linked characteristics of the Earth’s surface. The use to which we locate land could be grazing, agriculture, urban development, mining and other activities. While land cover categories could be cropland, forest, wetland, pasture, roads, urban areas, vegetation area are also among others. According to Meyer (1995), the term land cover originally referred to the kind and state of vegetation, such as forest or grass cover but it has broadened in subsequent usage to include other things such as artificial structures like building, soil type, biodiversity, surface and ground water.

Land use affects land cover and changes in land cover also affect land use. Changes in land cover by land use do not necessarily imply degradation of the land. However, many changing land use patterns driven by a variety of social causes, result in land cover changes that affects biodiversity, water and radiation budgets, trace gas emissions and other processes that come together to affect climate and biosphere(Riebsame, *et al*.,1994).

Land cover also can be changed by natural events such as weather, flooding, fire, climate fluctuations, and ecosystem dynamics may also facilitate variation upon land cover. Globally, land cover today is changed primarily by direct human use: by agriculture and livestock raising, forest harvesting and management and urban and suburban construction and development. There are also other determinant factors on land cover from human activities such as forest and grass damaged by acid rain and crops near cities damaged by troposphere ozone resulting from automobile exhaust. Therefore, in order to use land efficiently, it is not only necessary to have the information on existing land use land cover but also the capability to monitor the dynamics of land use resulting from both changing demands of increasing population and forces of nature acting to shape the landscape (Meyer, 1995).

According Morgan (2005), ground cover exert a strong moderating impact on the energy supplied by agents of soil erosion especially rain drop. Soil erosion would be increased if the soil has no or very little vegetative cover of plants and crop residues. Plant and residue cover protects the soil from raindrop impact and splash, tends to slow down the movement of surface runoff and allows excess surface water to infiltrate. The erosion reducing effectiveness of plant and residue covers depends on the type, extent and quantity of cover. Vegetation and residue combinations that completely cover the soil, and which intercept all falling raindrops at and close to the surface are the most efficient in controlling soil erosion (e.g. forests, shrubs and permanent grasses).

2.3 Role of Remote Sensing in Land Use and Land Cover Change Detection

Planners and resource managers want a reliable mechanism to assess the consequence of the changes resulted by the stress forced on natural resource by detecting, monitoring, and analyzing land use land cover changes quickly and efficiently. The conventional method of environmental data collection and analysis are not efficient in delivering the necessary information in a timely and cost effectively fashion. Hence, viewing the earth from space has become essential to realize the collective influence of human activities on its natural resource base. Remote sensing technology however can play a vital role in providing accurate and reliable information with cost effective and lesser time compared to other methods (Lillesand and Kiefer, 2000).

Remote sensing gives us a viable source of data from which updated land cover information can be extracted efficiently and cheaply in order to record and examine these changes effectively. Thus change detection has become a major application of remotely sensed data because of repetitive coverage at short intervals and consistent image quality (Mas, 1999).

According to Lillesand *et.al.,* (2005) discussed about the importance of Remote Sensing in the development of various environmental management methodologies, providing the following advantages when compared to conventional ground based methods (1) **synoptic view**-Remote sensing facilitates the study of various features of earth's surface and the spatial relationship .between features; (2) **Ease of access**-Remote sensing makes it possible to gather information about areas that are not accessible for ground surveys, like mountainous areas or foreign lands, and (3) **Time**-Since information about a large area can be gathered quickly, these techniques save time and effort.

Satellite imagery has been well used in the natural science communities for measuring qualitative and quantitative earthly land cover changes (Campbell, 2002). Qualitative changes in landscapes occur either as natural phenomena (lightning strikes, storms, pests) or can be human induced (selective logging, agro forestry). Quantitative land cover change is the wholesale categorical transformation of the land, and although it can occur as a natural phenomenon as caused by fires and storms, large scale replacement of one land cover type by another is usually induced by human activity (forest clearing, agricultural expansion, urban growth). Both qualitative and quantitative changes in land cover have been successfully monitored with remote sensing, with research dominated by efforts at monitoring change in vegetation and forest canopies.

2.4 Application of Remote Sensing and GIS to Monitor Forest Cover Change

The application of Remote Sensing is a powerful technique for surveying, mapping and monitoring earth resources. This technology combined with GIS which outperform in storage, manipulation and analysis for geographic information and socio-economic data to provide a wider application. The terrain resource and environmental decision makers require quantitative information on the spatial distribution of land use types and their conditions as well as temporal changes. The potential of remote sensing and GIS in the field of forestry become established over many years through the use of aerial photos and satellite image interpretations in forest cover change detection analysis, for the production of cover map and inventory analysis (Lillesand et al., 2008).

Remote sensing can brings together a large number of tools to better analyze the scope and rate of deforestation. Multi temporal data gives for change detection analyses. The Images of earlier years can compared with the recent scenes, to physically measure of the differences in the sizes and extents of forest cover change. Data from a variety of sources are used to provide complementary information. Satellite image data can be used to efficiently monitor the status of existing clear cuts or emergence of new ones, and even assess to regeneration condition. But in countries where the cutting of forest is controlled and regulated, remote sensing serves as a monitoring tool for evaluation.

2.5 Normalized Difference Vegetation Index (NDVI)

As Lillesand et al., (2008) states that NDVI is an index commonly used when observing global vegetation. It measures the density of the vegetation cover and is often used to monitor photosynthetic activity at regional and global scale in order to detect vegetation fluctuations (Seaquist et al., 2002). Since vegetation reflects red and near-infrared light it is possible to calculate the NDVI.

The NDVI is calculated by subtracting the near-infrared radiation it with the red band value and then divide it by near-infrared radiation added with the red band value. The red light is absorbed by chlorophyll in plant leaves and used in the photosynthesis. The near-infrared light is reflected by the cell structure of green leaves. As Lille sand et al., (2000) describes that the calculated NDVI results in a value between -1 and +1. Less or no vegetation gives the value of 0 or close to 0 and high density of vegetation results in a value close to 1.While, the negative values correspond to presence of clouds, water or snow. Whereas a value near zero means in general rock and bare soil.

2.6 Vegetation Mapping and Monitoring

Kuckler and Zonneveld (1988) pointed out that the nature and properties of vegetation are fundamental attributes of landscapes. The nature of the vegetation in an area is determined by a complex combination of effects related to climate, soils, history, fire and human influences. Vegetation mapping has a long history which includes a variety of contexts and a wide range of geographic scales. Maps of possible vegetation attempt to determine what the vegetation type would be in the absence of human influences. Maps of real vegetation attempt to characterize the vegetation as it exists in an area.

Monitoring of vegetation change using remote sensing is presenting a better understanding of the health and condition of vegetation as well as rates of conversion of natural vegetation to other land uses. The first vegetation maps made with the help of remote sensing were based on the visual interpretation of aerial photographs (Lillesand et al., 2008). With the beginning of the Land sat program in 1972, there was a direct interest in the possible for mapping vegetation over larger areas in more efficient manner than traditional air photo interpretation. Different active research and several approaches are concerned for using digital satellites images for mapping vegetation. These includes classification using per-pixel classifiers; using spatial or contextual information in the classification process (Kettig and Landgrebe, 1976; Stuckens et al., 2000), and using segmentation of images into polygons in a step independent of image classification (Woodcock and Harward, 1992).

The major aspects that are focused when monitoring natural environment and land cover changes are includes the extent of the change (the magnitude of the change), the nature of the change, and the spatial pattern of the change measuring the spatial distribution and relationship of the change (Sepehry and Liu, 2006). In the examination of land use and land cover change; firstly it is essential to conceptualize that meaning of change to detect its real situations. However, both in the case of land cover as well as of land use, the meaning and conceptualization of change is much broader.

In the case of land cover change, the relevant literature distinguishes between two types of change: conversion and modification (Skole and Tucker, 1993). The land cover conversion involves a change from one cover type to another while land cover modification involves alterations of structure or function without changing from one type to another. There are many factors which influence the vegetation condition and health, ranging from drought to acid rain and air pollution. Remote sensing presented an alternative approach whose strength is spatial coverage, when combined with ground sub-region of ground sampling shows to be extremely helpful for monitoring vegetation health.

2.7 Image Classification and Analysis

Digital image classification is the process of assigning pixels to classes. Usually, each pixel is treated as an individual unit composed of values in several spectral bands. It is divided into supervised and unsupervised classification. The first category is unsupervised classification. Unsupervised classification uses statistical clustering techniques to combine pixels into groups (classes) according to the degree of similarity of their brightness value in each spectral band. The analyst should understand the spectral characteristics of the terrain in the area of study well enough to properly label certain clusters into a specific information class (land cover type). In this process many spectral classes can be assigned to a few land cover types (Jensen, 1996).

The second category is supervised classification. Supervised classification is the process of using a known identity of specific sites (through a combination of fieldwork, analysis of aerial photography, maps, and personal experience) in the remotely sensed data, which represent homogenous examples of land cover types to classify the remainder of the image. These areas are commonly referred to as training sites (Jensen, 1996). The maximum likelihood classifier is one of the most popular methods of classification in remote sensing. This classifier assigns a pixel with maximum likelihood into a corresponding class. Selecting the appropriate bands to use in the color image on the other hand does have a huge impact on which features can be seen in a particular image during classification.

Aerial photography is used to receive reflective signal from the visible and near infrared portion of the spectrum. Most digital scanners operate in similar portion of the spectrum. Thermal and radar sensor systems are sensitive to the different portion of the energy spectrum. Remotely sensed data provides an operational GIS with timely and synoptic data. Remotely sensed data includes a variety of data source that are defined from the range of spectrum of electromagnetic radiations. Image analysis techniques are commonly utilized to perform regional vegetation mapping and to update existing vegetation maps (Jensen, 1995).

According to Jensen (1995), the utility of a sensor system for the detection of surface phenomena must be assessed along four dimensions: spatial resolutions (area or size of features that can be identified), spectral resolution (number and width of electromagnetic bands for which data are collected), radiometric resolution (detector sensitivity to various level of incoming energy) and temporal resolution (frequency of satellite overlaps). Airborne and satellite digital sensor collect and store data values for discrete units of the surface of the earth. A scene is composed of large matrix of these cells. Each cell is referred to as a picture element or pixel and may correspond to a square meter, hectare or square kilometer, depending on the sensor. The spatial resolution of the sensor is usually expressed as the length of one side of the cell. AVHRR has spatial resolution of 1.1 km (Kidwell, 1988); MSS) resolution is 80 m and TM 30 m.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. The study area

3.1.1 Location

The study area is located in Northern Ethiopia, particularly in the eastern zone of Tigray Regional State (Figure 3.1). It is located in the western tip of Hawzen Woreda. It is situated some 27 km south west of Hawzen town and covering an area approximately 8227.08ha. The geographical location of the area is between $13^0$47''N to $13^0$55'N latitudes and $39^0$13'E to $39^0$17'E longitudes. The area is accessed through dry weather road which runs from Hawzen through Megab westward. Koraro is one of the 25 administrative villages that make up the Hawzen Woreda. Koraro Tabia is further divided to 3 sub villages (Kushets) known as Koraro, Tonsoka and Tala.

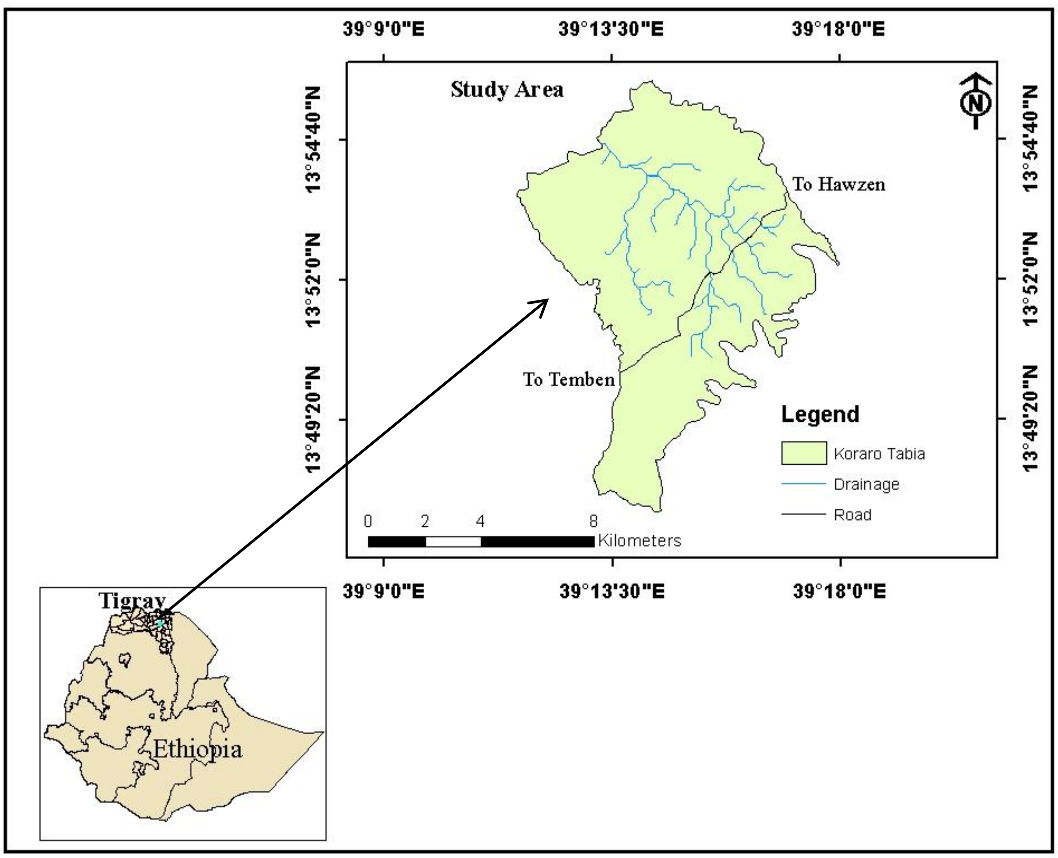

Figure 3.1 Location map of the study area with respect to Ethiopia

3.1.2 Topography

Topography expresses the physical features of a surface area including relative elevation and position of natural features. The area is characterized by a highly elevated land mainly composed of sandstone in southeast and east, and a relatively flat and lower elevation portion in the west and northwest. According to the socio-economic baseline survey carried out by the Eastern Zone Department of Planning and Economic Development (2006), the village has a very undulating nature of topography with sharp pointed mountains and lowland areas. Generally, the altitude of the village varies from the lowest point, which is as low as 1600 meters above sea level at Agefet and Werie rivers to 2350 meters above sea level at a particular place called Abunegerecheal Mountain.

Slope is another expression of topography. It can be defined as the upward or downward inclination of a natural or artificial surface or it is a deviation of the surface from the horizontal. According to the modified FAO, 1999 classification, the slope of study area has been categorized into seven classes as indicated in Figure 3.2.

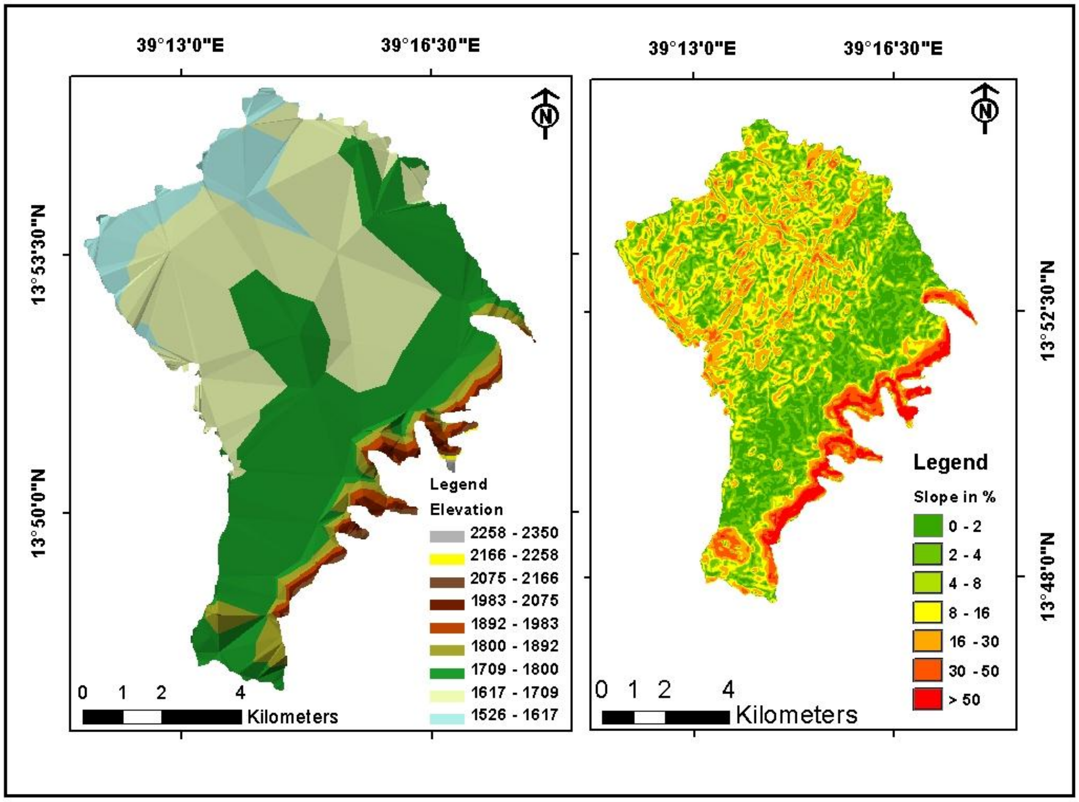

Figure 3.2Topographic condition of the study area

3.1.3 Climate

The traditional Ethiopian classification of climatic zones is based on altitude and temperature. Using this system Ethiopia is divided to different climatic zones. According to Hawzen office of agricultural and rural development (2014), the climatic zone of the study area is generally characterized by Kolla climate.

3.1.3.1 Temperature

Temperature is one element of climate which determines the hotness and coldness of the given area. According to Hawzen office of agricultural and rural development, the minimum and maximum daily temperature ranges between 17^0C to 25^0C respectively with its averages of 21^0c.

3.1.3.2 Rainfall

Rainfall is the most economically important for crop production. The average annual rainfall is between 81 and 177.2 mm. February, March and May are the hottest months and November and December are the coldest months. The long-term (1997–2013) total and mean annual rainfall recorded by Hawzen Office of Agricultural and Rural Development is described in appendix III. But the rainfall for the months of October, November, December and January were not recorded.

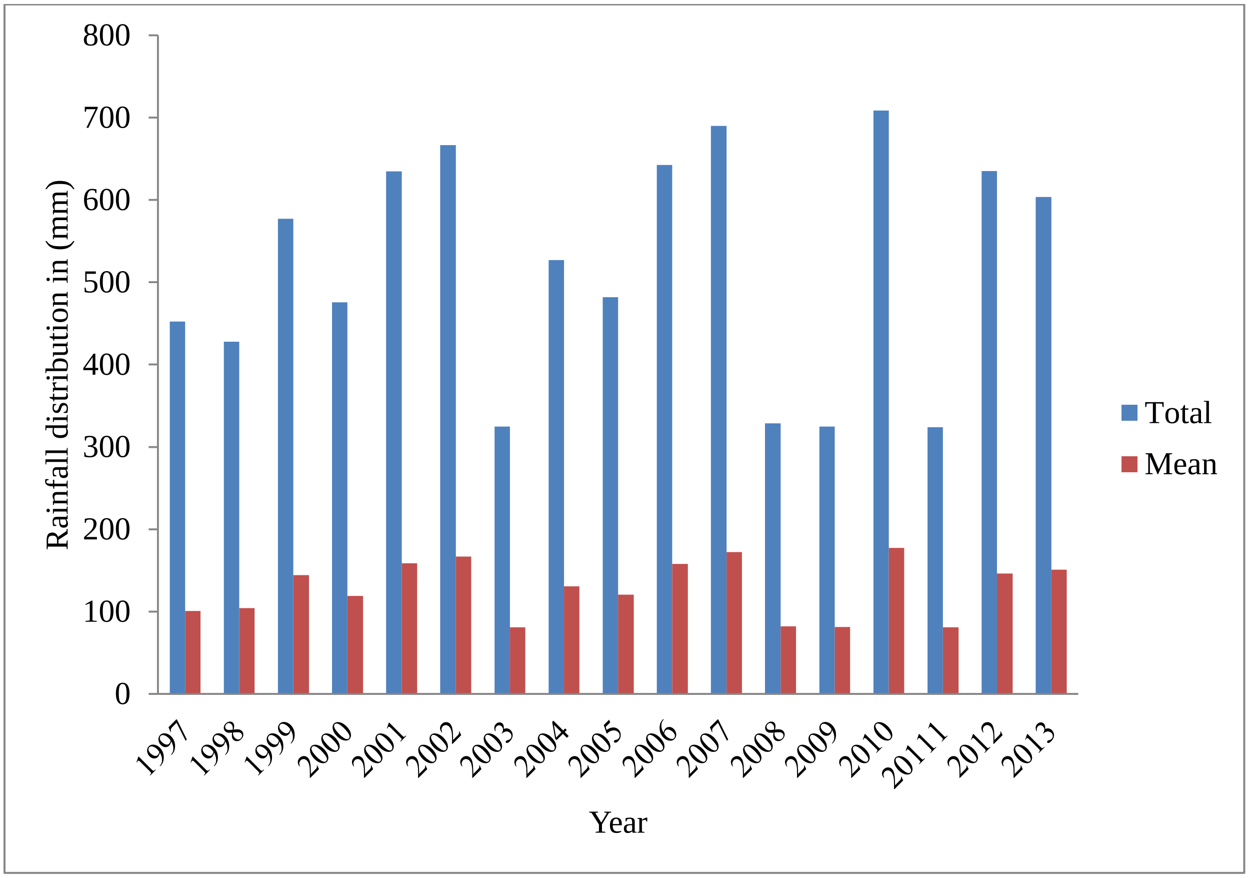

Figure 3.3 Rain fall distribution of Koraro

3.1.4 Drainage

The area portrays a dendritic drainage pattern. Most of the drainage flows from south east towards North West. The seasonal stream named as Siglti with its tributaries such as Tenseka, Dagbatat and Af Tsebib (Figure 3.4).

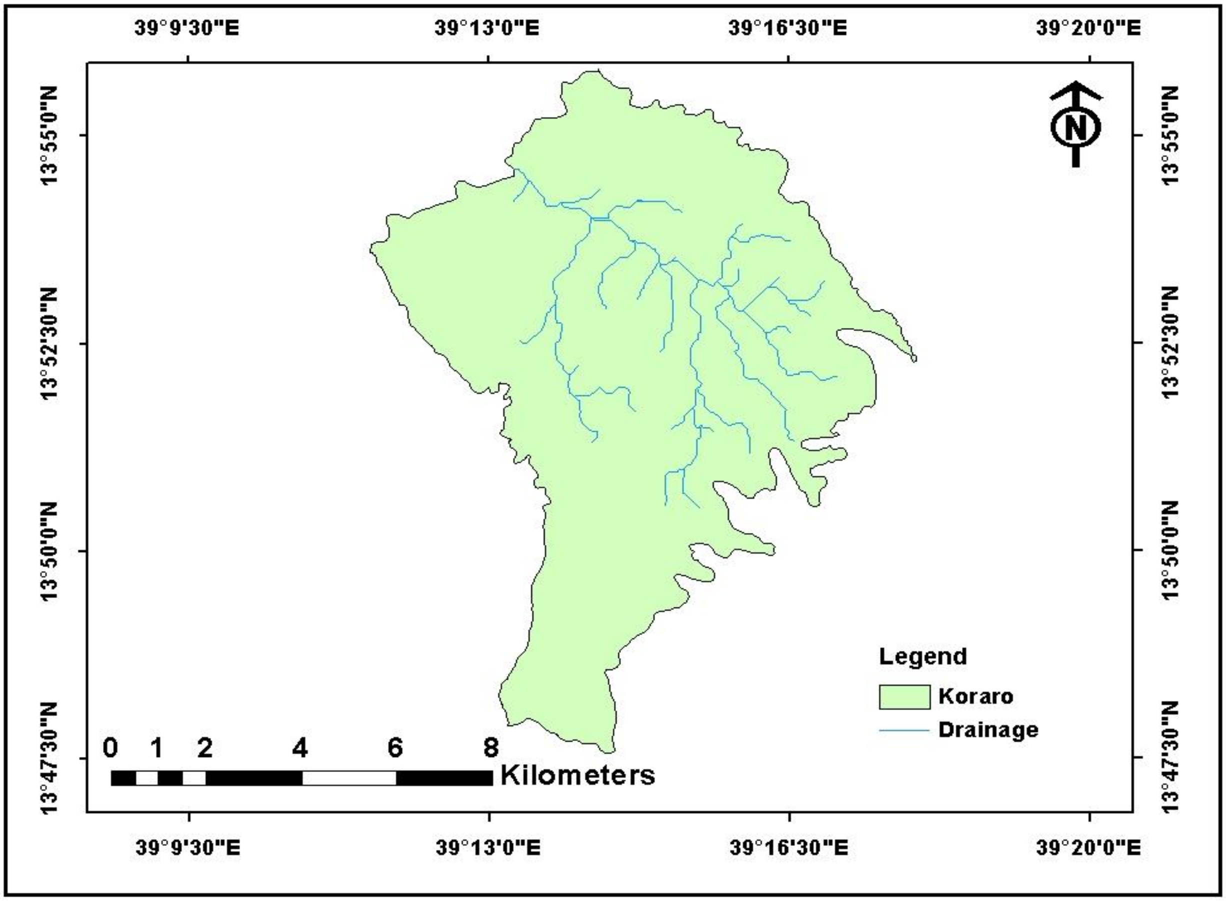

Figure 3.4 Drainage pattern of the study area

3.1.5 Land use and Land Cover

The land use and land cover of the study area is grouped in to four divisions, namely, farmland, vegetation area, bare land and settlement. The total land cover of the study area is 8227.08 hectares. Traditional agriculture is the most important form of land use.

3.1.6 Population

According to the Population and Housing Census of Ethiopia (2007), the study area had an estimated total population of 5052, of which 2425and 2667 were males and females respectively with the growth rate of 2.1%. During the population census of 2007, the population density had approximately 61 people per square kilometer of land. According to this census, the estimated population in 2014 is 6546 of which 3291, 3295 are males and females respectively. In addition to this, due the population and housing census of Ethiopia in 2007, the households' sizes were 1098. But now a day's with the growth rate of the households which is 4.6%, the estimated households of the 2014 is to be a total of 1423 and the area of land per household is approximately 17 households per square kilometer of land.

3.1.7 The Activities of Livelihood

According to Hawzen Office of Agricultural and Rural Development (2014), agriculture is the backbone of the village's economy which is dominated by mixed farming. Farmers produce food crops like Teff, Maize, Sorghum and Millet and rear animals such as cattle, sheep, goat, donkey, poultry as well as honeybees. Nevertheless, it is traditional, backward and peasant farming dominated. Hence production and productivity were always extremely low, which do not allow the Woreda (district) to have self-sufficiency in food. The village had severe natural resource degradation and severe soil erosion prevails throughout the village. Vegetation covers were scanty. Gully erosion was another problem of the village, coupled with surface run off and lowering water table. Although efforts were being made to increase production and productivity of the Woreda, satisfactory outputs had never been achieved due to various factors such as recurrent droughts, poor implementation capacity and lack of application of appropriate agricultural technologies, etc.

To mitigate the above mentioned problems, different international donors like, the Millennium Village project had discussed and reached in a consensus with the community and Office of Agriculture and Rural Development of the Region and District to implement different activities such as soil and water conservation, gully plugging and reforestation, fruit seedlings and vegetable seed supply, improved seed and fertilizer supply, closing areas(area exclosure), livestock resource development and farmer training on new innovations etc. Due to these implementations, now a day, the vegetation coverage and agricultural production are increasing.

3.1.8 Integrated Watershed Management

Integrated watershed management was a new approach in the village to be implemented to tackle the problem of mismanagement of natural resources, to increase productivity of resources (water, soil, forest, etc.), to rehabilitate the degraded environment and thereby improve the productivity of the area. In connection with this, the community identified first a sub watershed area which has high runoff that is affecting vast areas of arable land located in the downstream. But now a day, according to Hawzen Office of Agricultural and Rural Development (2014) the watershed of the closed area extends beyond what was from the first. The Millennium Village Project in collaboration with World Food Program, Office of Agriculture and Rural Development and local community has implemented soil and water conservation, gully treatment and plantation of useful tree seedlings in the selected area.

3.2. Methodological design

3.2.1. Preliminary Field Visit

Preliminary field visit was carried out to get the all overview of the study area, to analyze the various land-use land cover types, compare the vegetation cover change and to collect GPS readings of the various features and land use land cover types.

3.2.2. Second Field Work Stage

The second field visit was taken to verify the various land use land cover types identified through satellite image manipulation and to consult the local community, and Office of Agricultural and Rural Development experts in order to identify the vegetation cover change and the GPS readings for the land use land cover type of the study area. In addition to this the local households and the agricultural experts' helped to given in-depth information about the impact of area exclosure on the livelihood of the peasant. These data were used for designing of final image classification and taking sample site, which was used for land and vegetation cover map validation. At each sampling site different reference points were used through GPS receiver for ground truth verifications.

3.3 Materials and Data sources

For this study GPS and Camera were used for ground truth and capturing photos in the study area. Software like, Arc GIS10, ERDAS Imagine 9.2 were used (Table 3.1). In addition to this other sources of data like Digital Elevation Model (DEM) and computer programs of Microsoft Excel were also used.

Table 3.1 Material with their purposes

Type	Description	Purpose
Instruments	GPS	Capturing geographic coordinate pointes
	Digital Camera	Capturing the real landscape features
Soft wares	Erdas imagine9.2	Analyzing satellite images
	Arc GIS 10	Analyzing Mapping

Satellite imageries have been collected in order to analyze historical and recent land use land cover and vegetation cover change with image processing for estimation of NDVI.

The NDVI can be calculated by using following formula:

$$NDVI = \frac{(NIR - R)}{(NIR + R)} \quad \text{(Equation 1)}$$

Where,

NIR = near-infrared radiation

R = Red band value

The satellite imageries for this study were Land sat L4-5 TM (1984, 1995, 2000 and 2010) and Landsat 8(2014). These satellites were taken at different months and dates, this because of the cloud cover. Therefore for the sack of clarity, the study was used at different times. The Digital elevation model (DEM) of the study area, with 30m by 30m resolution, from Aster Global DEM was obtained. These data were used to examine the land use land cover and the topography of the study area in general by using ERDAS Imagine 9.2 and Arc GIS 10 software. The types of satellites with their acquisition of dates, path and row, and resolution of the satellite images used in this study are summarized in Table 3.2.

Table 3.2 Types of satellites with their characteristics

Satellite	acquisition date	Path and row	Resolution
Landsat 4-5 TM	22/11/1984	169/50	30mx30m
Landsat 4-5 TM	27/04/1995	169/50	30mx30m
Landsat 4-5 TM	10/05/2000	169/50	30mx30m
Landsat 4-5 TM	14/09/2010	169/50	30mx30m
L8 TIRS	01/05/2014	169/50	30mx30m

3.4 Methods

In order to address the objectives, both primary and secondary data were used. The primary data were generated from the satellite image, field visits, in-depth interview with concerned bodies and questionnaires. The secondary data obtained from various published and unpublished sources of the governmental and the non-governmental organizations such as; books, journals, internet sources, research reports, articles, documents and records were employed for acquiring the necessary information

Objective One: to analyze the land use and land cover change for the last 30 years.

Data sources and data collection methods

Land sat satellite imageries of the study area were used to analyze the land use and land cover change in the study area. For analyzing the imageries, image processing (such as, ERDAS imagine 9.2) and GIS software (such as Arc GIS 10) were used. In addition to the remote sensing data, a series of discussions were made with the local community and the agricultural experts to get data about the past history and important landmarks in the management of natural resources for the land cover change. Field survey, aided by GPS was also used to obtain accurate ground truth for each land cover class to be included in the classification scheme.

Methods of data analysis

Land use land cover changes for the study area have been examined at time intervals from 1984 to 2014. The land use and cover classification was analyzed using supervised classification which involved image interpretation and detailed field-cross checking with numerous ground control points using GPS. Later, the satellite image was clipped to the frame that covers the study area. Then finally the land use land cover change has been done with the overall accuracy results and analyzed through the confusion matrix.

Objective two and three: analyze vegetation cover changes for the last 30 years; and to compare the vegetation coverage of watersheds with and without area exclosure. The aim is to investigate the contribution of area exclosures on vegetation cover change by comparing with in watershed of area exclosure and without exclosures.

Data sources and data collection methods

To detect the coverage of vegetation between 1984 and 2014 were examined through the multispectral Land sat Satellite images. Satellite imagery of the periods 2010 and 2014 were also used to detect the vegetation cover change of the watershed within and without after area exclosure. Intensive field survey was also carried out for the purpose of ground checks and to have a clear understanding to what extent it has been changed so far and evaluate achievements gained through vegetation conservation. The software ERDAS-9.2 and Arc GIS 10 were used for the processing.

Methods of data analysis

In order to detect the vegetation covers, NDVI was analyzed for the last 30 years. NDVI is an emerging technique from RS and GIS technology to detect spatial temporal change of vegetation cover (Ghorbani et al., 2012). The NDVI values of the two case studies of watersheds were compared to see the difference in vegetation cover. The vegetation cover changes have been also analyzed using the change detection method. The changes in vegetation covers of the two case studies of watersheds were quantified and compared using the NDVI simple descriptive statistical analysis.

Objective Four: analyze the impacts of the area exclosures on the livelihood of the local farmers.

Data sources and data collection methods

Field observation, series in-depth interview with community and agricultural experts, and questionnaires were used to get data about the impacts of the area exclosures on the livelihoods of the farmers. The study area covers three (3) villages or kushets which are Tonsoka, Koraro and Tala.

The area exclosure is located in the two villages, Tonsoka and Koraro. As the result of its location, the study collected a data from the two kushets of households who are located nearest towards area exclosure. In addition to this it is also collected from agricultural and rural experts.

In this study, simple random sampling for the households and purposive sampling techniques for the agricultural and rural experts were applied. 50% of respondents selected from the total households (n= 50) nearest towards area exclosure and 5 from the total agricultural experts. Therefore, a total of 30 respondents were taken.

Methods of data analysis

The data obtained from the observation and interviews were analyzed qualitatively, whereas the data obtained through questionnaire methods analyzed through quantitatively using excel.

Generally, the method followed in this study is presented (Figure 3.5). It shows the steps followed beginning from the acquisition and classification of satellite images of the study area to the extraction of the required information.

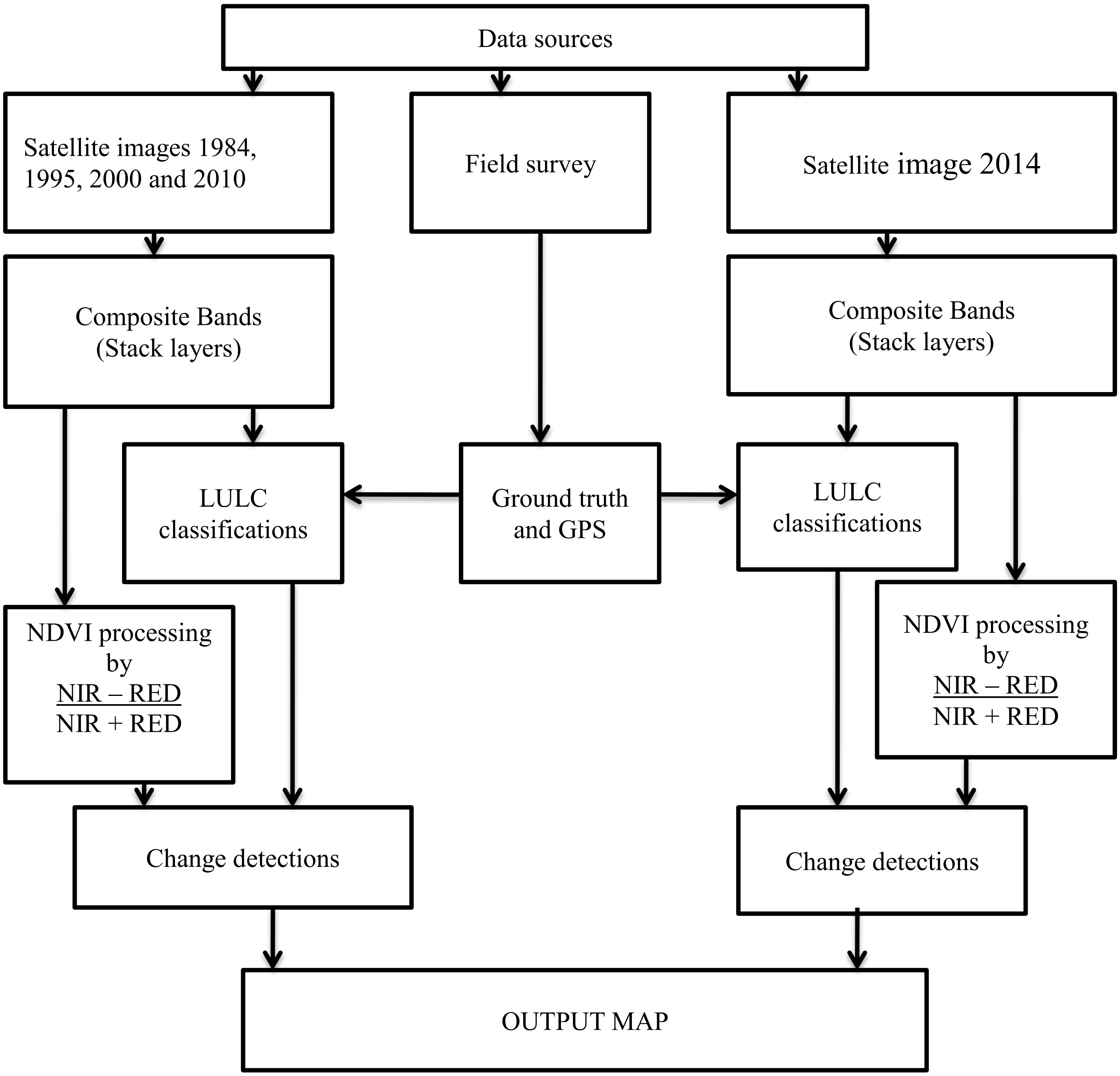

Figure 3.5 Framework followed for this study

CHAPTER FOUR

4. RESULTS AND DISCUSSION

4.1 Introduction

In this unit, so as to meet the objectives of the study, the following four important issues are presented their results: Land use and land cover change, vegetation cover change, comparing the vegetation coverage of watersheds within and without area exclosure, and finally the impacts of area exclosure on the livelihood of the farmers.

4.2 Results

4.2.1 Land Use and Land Cover Change

4.2.1.1 Land use land cover in 1984

Land use and land cover was classified in to four land use and land cover units; these are vegetation area, bare land, farmland and settlement. As it is clearly shown in Table 4.1 and Figure 4.1, the land use land cover classification results of the study area in 1984 were: farmland, bare land, settlement and vegetated area with 4348.71ha(53%),2218.77ha (27%), and 1010.07ha (12%) and 649.53(8%) respectively.

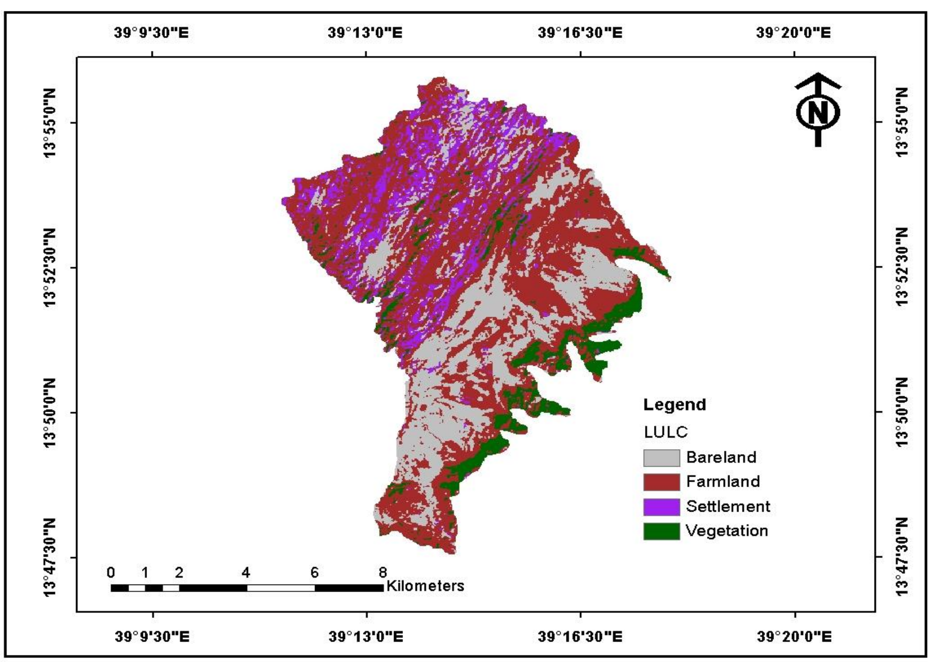

Figure 4.1 Land use land cover map of Koraro in 1984

4.2.1.2 Land use land cover in 1995

The land use land cover in the year 1995 show that the proportion of land use land cover for farmland(49%), vegetation (27%), settlement (15%) and bareland with 9% (Figure 4.2). The results of land use land cover from Table 4.1 shows that the area under vegetation and settlement patterns were increased in the period of 1995. The rate of increment was greater in the vegetation. While the reaming farmland and bare lands show general trend of decrease in the period 1995. This is just the general impression of land cover based on comparison of the land cover maps.

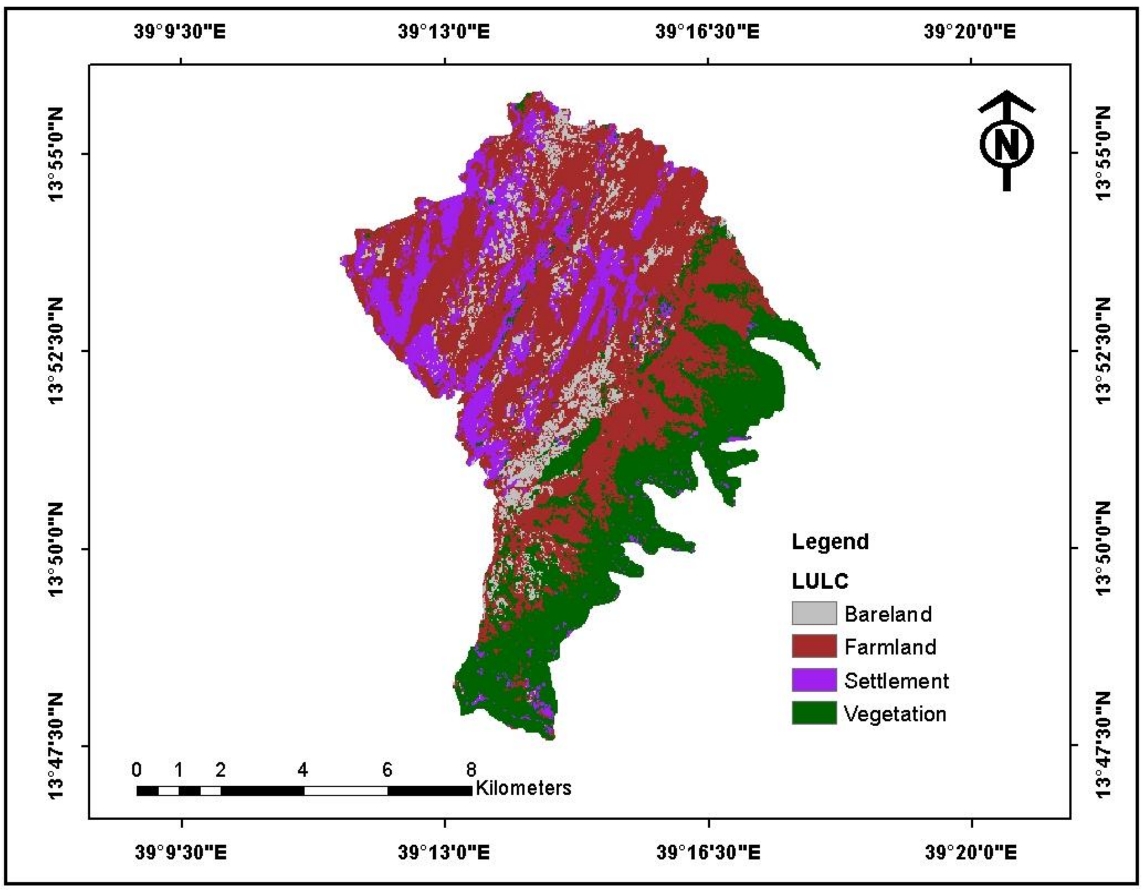

Figure 4.2 Land use land cover map of Koraro in 1995

4.2.1.3 Land use land cover in 2000

In the year 2000, the area of vegetation coverage units was about 1050.21ha (12.8%) of the total area and farmland accounts about 56.2% (Table 4.1).The remaining land category is under the bare land and settlement accounted 7.6%, and 23.4%, respectively. The results of land use land cover show that the area under vegetation and bare land coverage were declined in the period of

2000 (Table 4.1). The rate of increment was happened in the farmland and settlements. Based on the comparison of the land cover maps, vegetation and bare land show decreased trend in the year of 2000.

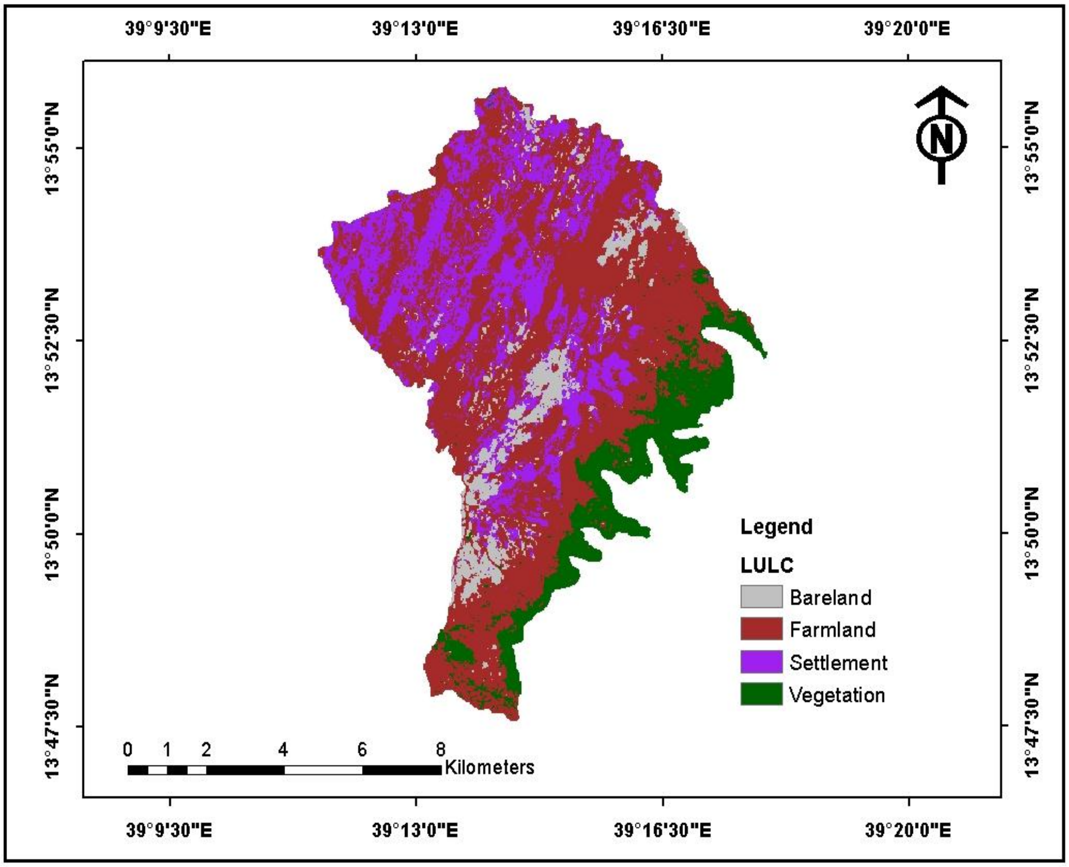

Figure 4.3 Land use land cover map of Koraro in 2000

4.2.1.4 Land use land cover in 2010

During the period of 2010, the area of vegetation coverage units was about 1297.61ha or 15.8% of the total area and land category under the bare land, farmland and settlement account around 4.94%, 51.56% and 27.7% respectively (Table 4.1). From the same year, it is also well noted that bare land and farmlands were decreased, while settlements and vegetation were increased as compared from the year of 2000. The increment of vegetation cover was due the area exclosure which were started in 2005 and settlements were due the rise of population pressure.

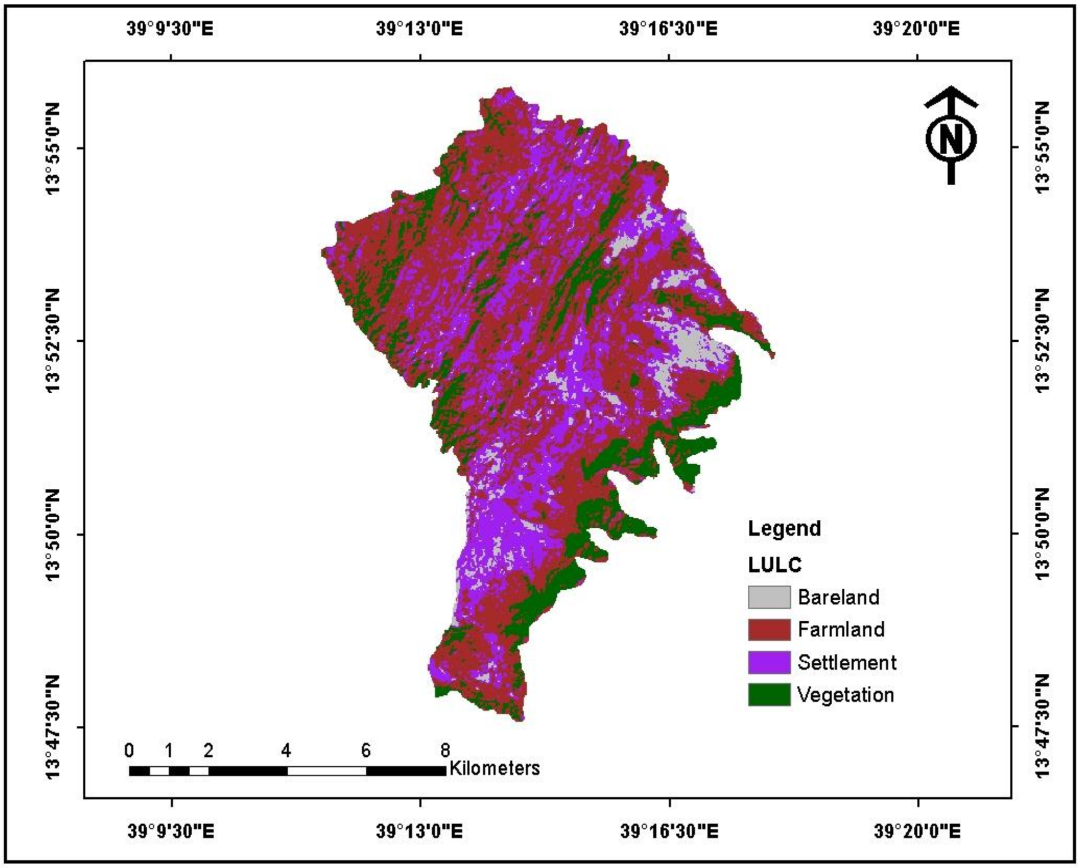

Figure 4.4 Land use and land cover map of Koraro in 2010

4.2.1.5 Land use land cover in 2014

In the period (year) 2014 the coverage vegetation was about 17% of the total land area. The land group under the bare land, farmland and settlement account around 6%, 47% and 30% respectively (Table 4.1). During this year the vegetation cover, settlements and bare land were increased, while farmland was decreased as compared from the year 2010. The increment of vegetation coverage was due to the area exclosure and the action of making rehabilitation mechanisms which were started in 2005. Settlements also increased due the rise of human population.

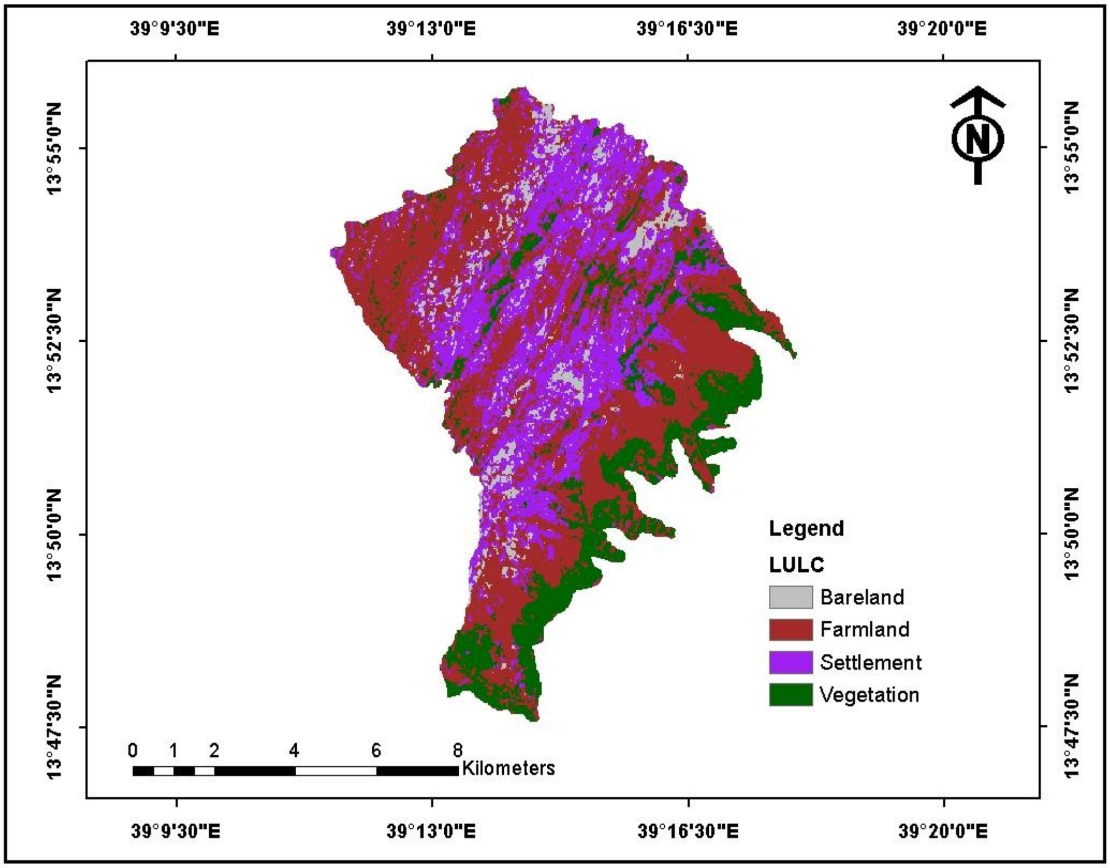

Figure 4.5 Land use and land cover map of Koraro in 2014

Table 4.1Summary statistics of land use land cover from1984 to 2014

Class Name	**Year** 1984(ha)	%	1995(ha)	%	2000(ha)	%	2010(ha)	%	2014(ha)	%
Vegetation	649.53	8	2220.4	27	1050.21	12.8	1297.61	15.8	1396.26	17
Farm land	4348.71	53	4044.8	49	4620.96	56.2	4243.06	51.56	3866.67	47
Settlement	1010.07	12	1261.17	15	1929.6	23.4	2279.25	27.7	2442.42	30
Bare land	2218.77	27	700.29	9	626.31	7.6	407.16	4.94	521.73	6
Total	**8227.08**	**100**	**8227.08**	**100**	**8227.08**	**100**	**8227.08**	**100**	**8227.08**	**100**
Over all accuracy	64.91%		65.12%		68.56%		73.21%		75.23%	

4.2.1.6 Land use land cover change from 1984 to 1995

The major cover changes observed from the year of 1984 to 1995 had been reduction in the area of both farmlands and bare lands from 4348.71 ha to 4044.78 ha and 2218.77 ha to 700.29 ha respectively. The remaining had been increased from the year 1984 to 1995(Table 4.2).

Table 4.2 Land use land cover change matrix between 1984 and 1995

		1984				
	Class Name	Vegetation	Farmland	Settlement	Bare land	Total
1995	Vegetation	474.93	1080.27	2.34	663.3	2220.84
	Farmland	22.05	2295.63	669.51	1057.59	4044.78
	Settlement	152.55	903.78	184.5	20.34	1261.17
	Bare land	0	69.03	153.72	477.54	700.29
	Class Total	649.53	4348.71	1010.07	2218.77	8227.08
	Class change	174.6	2053.08	825.53	1741.23	

4.2.1.7 Land use land cover change from 1995 to 2000

Table 4.3 shows that there is a reverse trend in some parts of the land use land cover from the previous years. The area covered by vegetation and bare lands were decreased while the area covered by farmlands and settlements types increased. The major change observed in this interval, vegetation and bare lands were decreased from 2220.84ha (1984) to 1050.21 ha (1995), and 700.29 ha (1984) to 626.31ha (2000) respectively. The other change in farmland from 4044.78 ha to 4620.96 ha and settlements from 1261.17 ha to1929.6 ha were increased from the year of 1995 to 2000.

Table 4.3 Land use land cover change matrix between 1995 and 2000

		1995				
	Class Name	Vegetation	Farmland	Settlement	Bare land	Total
2000	Vegetation	990	27	33.12	0.09	1050.21
	Farmland	1132.29	2189.7	1104.84	194.13	4620.96
	Settlement	27.54	1604.16	119.61	178.29	1929.6
	Bare land	71.01	223.92	3.6	327.78	626.31
	Total	2220.84	4044.78	1261.17	700.29	8227.08
	Class change	1230.84	1855.08	1141.56	372.51	

4.2.1.8 Land use land cover change from 2000 to 2010

Land use land cover type in areas of both farmlands and bare lands were decreased while vegetation and settlements had been increased (Table 4.4). The total of the farmlands and bare lands decreased from 4620.96 ha to 4243.05ha, and from 626.31ha to 407.16 ha respectively from the years 2000 to 2010. The critical point for the increment of vegetation coverage in this time interval was due the vegetation rehabilitation mechanisms of area exclsoure.

Table 4.4 Land use land cover change matrix between 2000 and 2010

		2000				
	Class Name	Vegetation	Farmland	Settlement	Bare land	Total
2010	Vegetation	549	661.86	86.76	0	1297.62
	Farmland	396.81	2596.14	1150.47	99.63	4243.05
	Settlement	65.7	1172.16	672.66	368.73	2279.25
	Bare land	38.7	190.8	19.71	157.95	407.16
	Class Total	1050.21	4620.96	1929.6	626.31	8227.08
	Cass change	501.21	2024.82	1256.94	468.36	

4.2.1.9 Land use land cover change from 2010 to 2014

As shown from Table 4.5 the major cover changes observed from the year of 2010 to 2014, is reduction in farmlands from 4243.05ha to 3866.67 ha. While the others land use land cover type are increasing as shown in Table 4.5.The increment of vegetation coverage in this time interval is also due the area exclosure and the action of making rehabilitation mechanisms. The increment of settlement patterns in this time interval also due to the rise of population number.

Table 4.5 Land use land cover change matrix between 2010 and 2014

		2010				
	Class Name	Vegetation	Farmland	Settlement	Bare land	Total
2014	Vegetation	772.47	607.05	16.11	0.63	1396.26
	Farmland	492.93	2322.36	816.75	234.63	3866.67
	Settlement	32.22	1246.5	1127.07	36.63	2442.42
	Bare land	0	67.14	319.32	135.27	521.73
	Class Total	1297.62	4243.05	2279.25	407.16	
	Class change	525.15	1920.69	1152.18	271.89	

4.2.2. Vegetation Cover Change

4.2.2.1. Vegetation Cover from 1984 to 2104

NDVI image differencing cannot provide detailed change information. It can only give the information of increase or decrease in NDVI value. The negative NDVI values indicate less or no vegetation cover, whereas the positive value indicates healthier vegetation.

The mean of NDVI value in the year 1984 was 0.14 and increased to 0.20 in the 1995(Table 4.6). But the NDVI value from 1995 to 2000 was decreased from 0.20 to 0.16. The remaining from the year of 2000 towards 2014 is increased (Table 4.6). The summary statistics of the NDVI values of the years from 1984-2014 is shown in Table 4.6. In addition to Table 4.6 there was a change in NDVI values and can examine the trend clearly from the Figure 4.7 given in the five years.

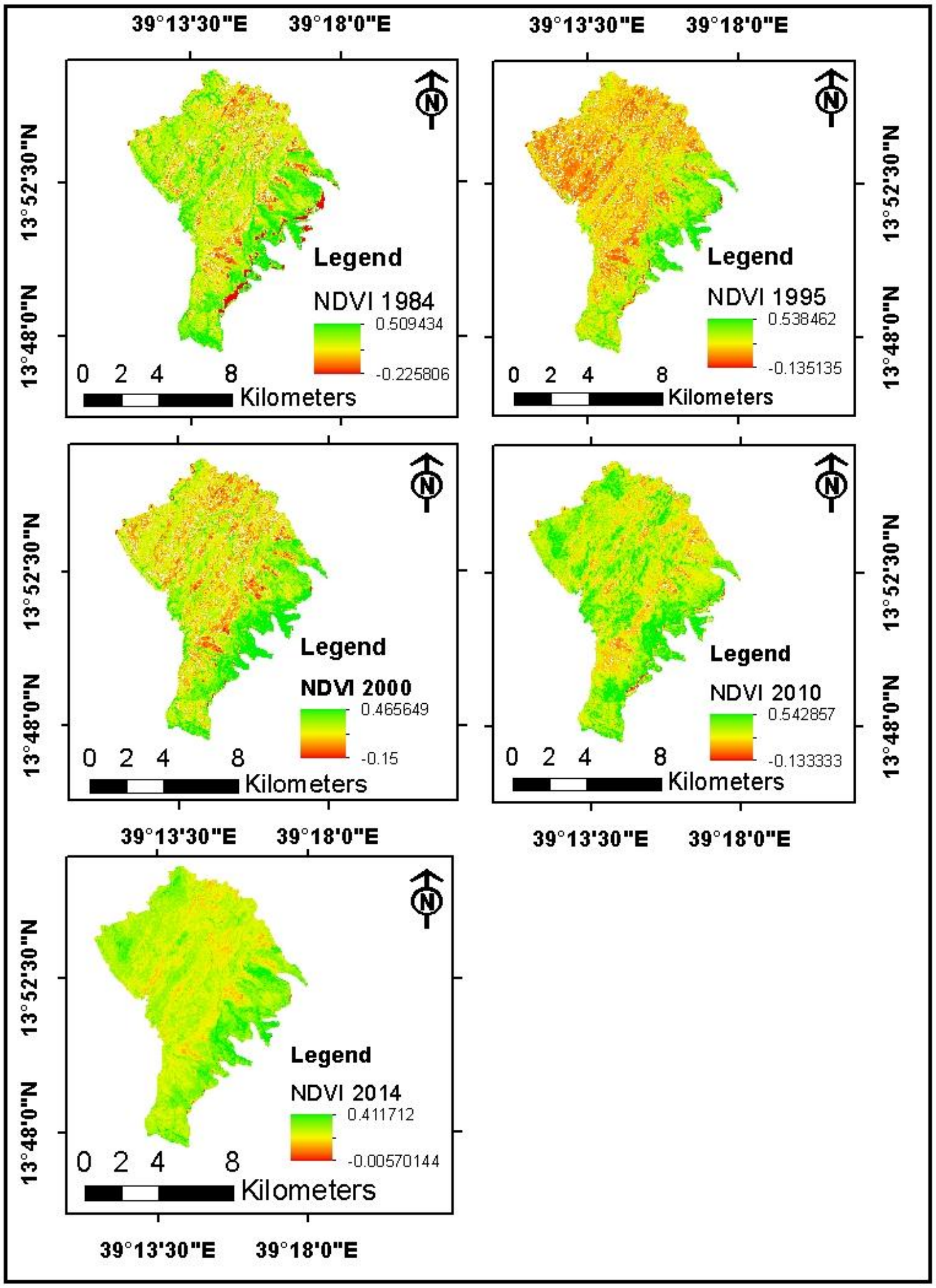

Figure 4.6 NDVI Map of the study area in 1984, 1995, 2000, 2010 and 2014

Table 4.6 Statistical data of the NDVI values of vegetation covers in Koraro

	Year				
Type	**1984**	**1995**	**2000**	**2010**	**2014**
Minimum	-0.23	-0.14	-0.15	-0.13	-0.01
Maximum	0.51	0.54	0.46	0.54	0.41
Mean	0.14	0.20	0.16	0.20	0.20

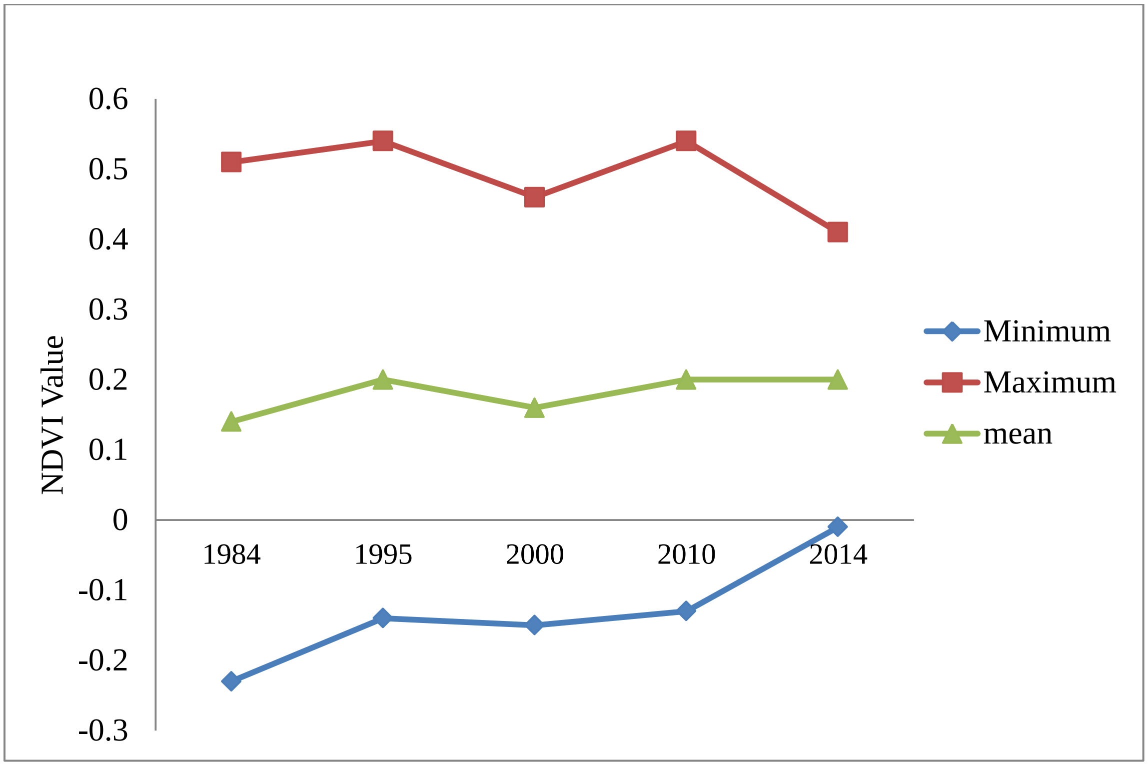

Figure 4.7 NDVI values at distribution (1984, 1995, 2000, 2010 and 2014)

4.2.2.2 Detection of Vegetation Cover Change through NDVI

The vegetation cover change from the year 1984 to 1995 was increased majority of the southeastern and decreased north western part, while the other part of the study area was unchanged. But from the year of 1995 to 2000 the change was inversely related from the previous detection. The detection change from the year 2000 to 2010 was dramatically increased in the vegetation cover as compared from the previous detection of 1995 to 2000. The majority of detection in vegetation coverage from 2000 to 2010, except the south eastern was increased. Likewise the detection from 2000 to 2010, there was also a great increment of change from the year 1995 to 2014(Figure 4.8).

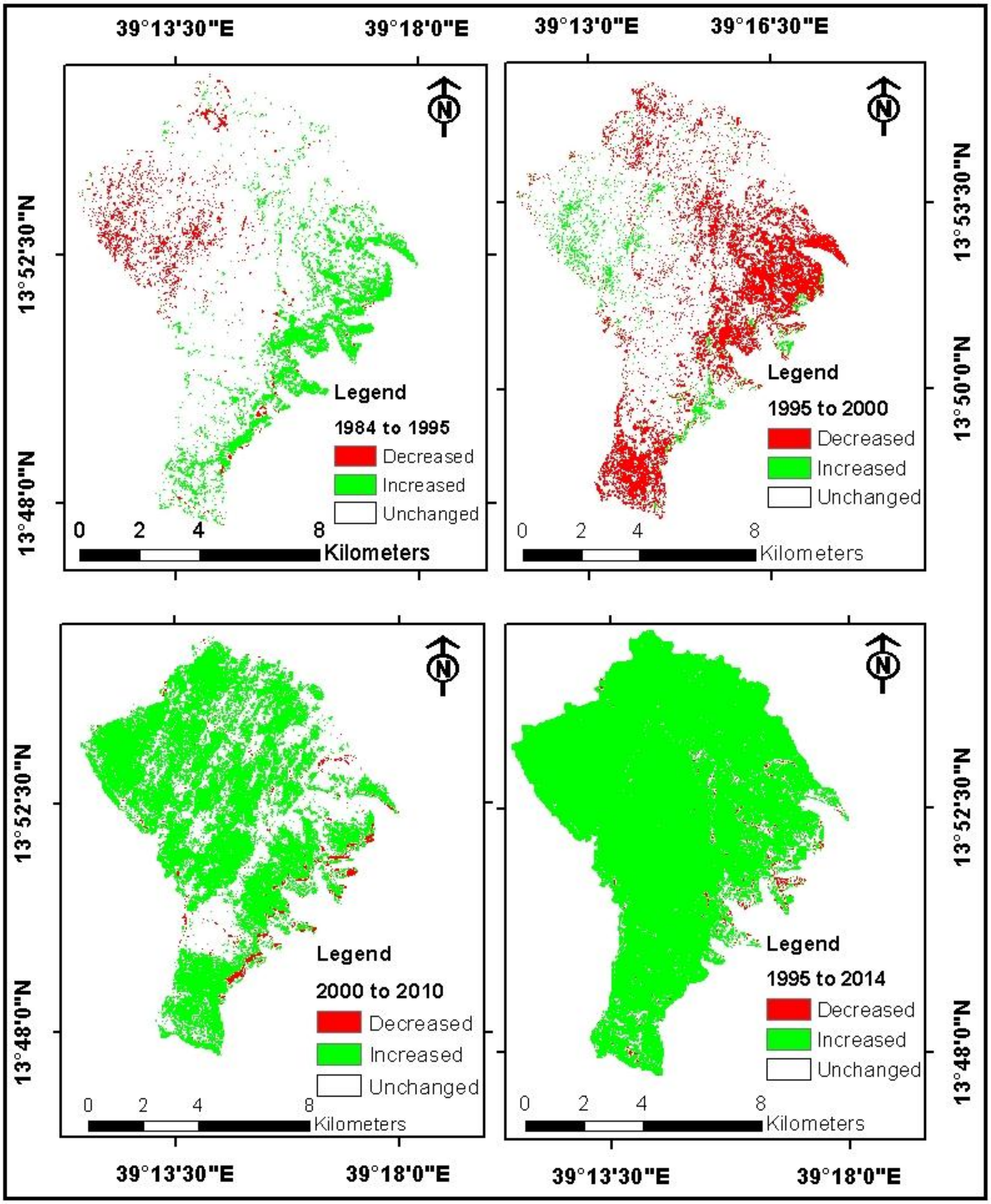

Figure 4.8 Detection of NDVI Map between different years

4.2.3 Comparison of Vegetation Coverage with and without Area Exclosure

From Figure (4.9) and Table (4.7) sample points were taken and comprehend the NDVI value of 2010 with in the area exclosure was high as compared to that of area without area exclosure in the different sub watersheds. The result indicates that the proportion of vegetation coverage with area exclosure is high, while the vegetation coverage without exclosure is low. Like that of 2010, the NDVI value of 2014 with area exclosure as indicated in Figure 4.9 is also high as compared that of area without area exclosure. This indicates that, the vegetation coverage and density with area exclosure is high, while the inverse is low.

Table 4.7 The NDVI values of sample points

	2010			**2014**		
Sample points	**Maximum**	**Minimum**	**Mean**	**Maximum**	**Minimum**	**Mean**
1	0.19	0.01	0.1	0.19	0.01	0.01
2	0.31	-0.03	0.14	0.17	0.048	0.1
3	0.3	0.01	0.15	0.21	0.08	0.14
4	0.33	-0.02	0.15	0.14	0.04	0.09
5	0.17	-0.09	0.04	0.18	0.05	0.1
6	0.46	0	0.23	0.4	0	0.2

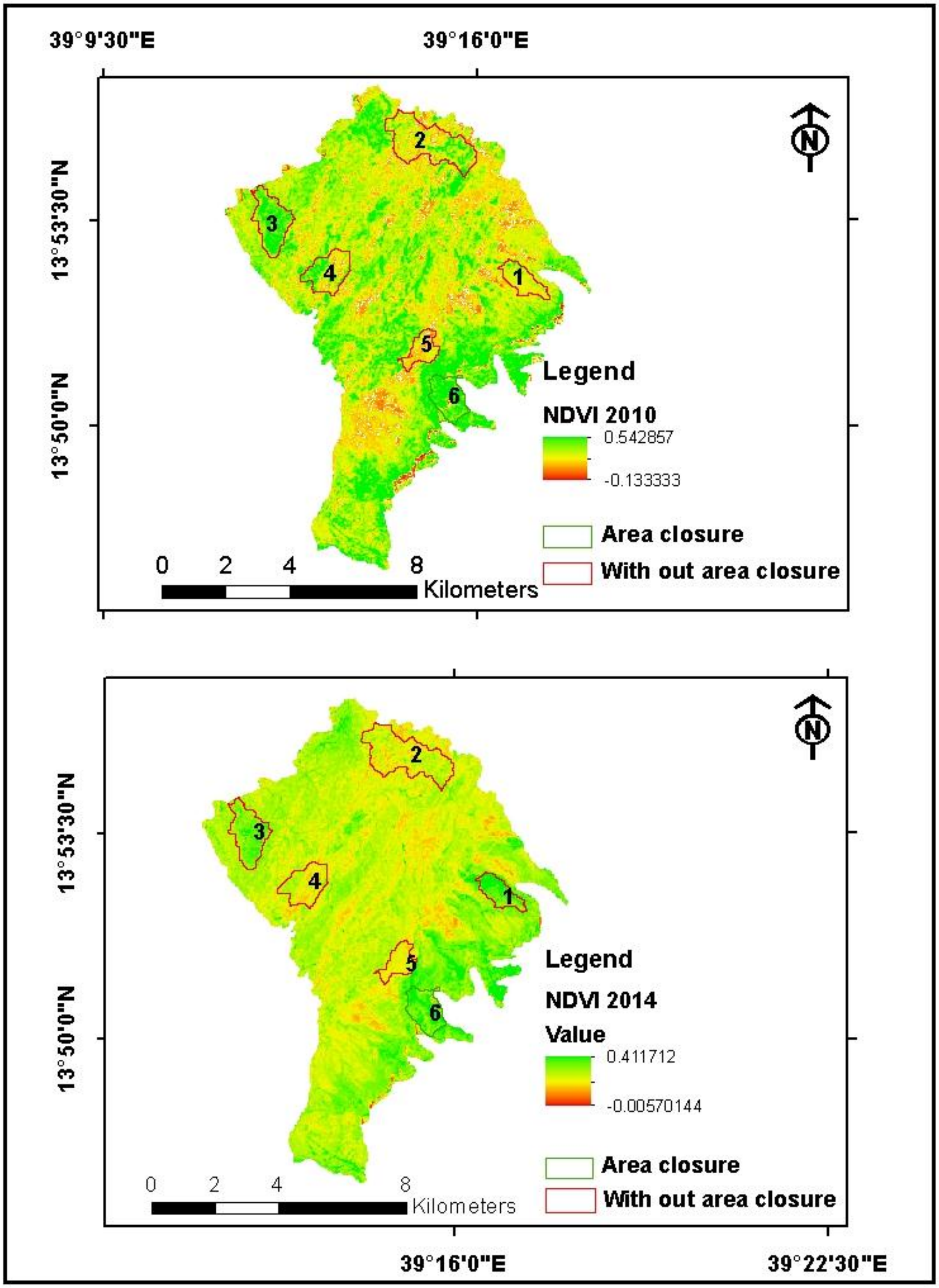

Figure 4.9 NDVI Map of the study area within exclosure and without exclosure

4.2.4 Impacts of the Area Exclosure on the Livelihood of the Farmers

Respondents had positive attitude towards the existence and expansion of area exclosure in their locality (Table 4.8). Majority of the respondents responded that the objective of the area exclosure was to rehabilitate the degraded lands and to protect the environment from future degradation. The peasants showed interest on further conservation and establishment of exclosures as one of the main rehabilitation mechanisms to tackle the problem of land degradation in the area and to come with coverage change in vegetation through area exclosure. On the contrary, some of the respondents disagreed that the establishment of the area exclosure restricts their access to grazing and farmland.

Social acceptance of a given project or work is one of the criteria for its sustainability. In agreement with FAO (1999), the acceptance of the local community and participation in the management activities of exclosures is vital for the overall environmental protection. From this, it can be deduced that the local people in the study area have the feeling of owning the area exclosures and the responsibility to participate and keep area exclosures from degradation.

Table 4.8 the impact of area exclosure on the livelihood of the framers

Impact of area exclosure on:	**Respondents**	**Responses**					
		Increasing		**No change**		**Decreasing**	
		frequency	**%**	**frequency**	**%**	**Frequency**	**%**
Reduction of soil erosion	Aexp	4	80	1	20	0	0
	HHds	18	72	4	16	3	12
	Total	22	73	5	17	3	10
Crop Production	Aexp	4	80	1	20	0	0
	HHds	17	68	6	24	3	8
	Total	21	70	7	23	3	7
Fodder availability	Aexp	5	100	0	0	0	0
	HHds	19	76	3	12	3	12
	Total	**24**	**80**	**3**	**10**	**3**	**10**

As the amount of bare soil reduces, infiltration rates can exceed rainfall intensity, which drastically reduces the erosion rate. Soils are particularly vulnerable to raindrop splash in areas with sparse vegetation. Majority of the households' respondents (72%) revealed that the reduction of soil erosion was as a result of area exclosure (Table 4.8). In addition to this, 80 % the agricultural experts also responded that the reduction of soil erosion is due to the establishment of area exclosure. But some of the respondents from households revealed that the reduction of soil erosion is increasing with the proportion of 12 %. Others also responded that the reduction of soil erosion is unchanged even if the existence of area exclosure (20 % agricultural experts and 16 % of households respectively).

The situation before the establishment of area exclosures, there had been serious wearing of soil of the farmlands and as result farmers' lost large amount of soil from their crop land. In this regard, the respondents perceived that there was a large difference between the rate of soil erosion of those farm lands adjacent to exclosure areas and open grazing land (Figure 4.10 or 4.11 against Figure 4.12). As a result the rate of erosion on those farmlands adjacent to the open grazing land is exposed to very low productivity on their farmland. As a result of this the farmers are exposed to increase in costs of agricultural inputs like fertilizers.

Soil erosion between the two catchments is different. The soil erosion within area exclosure is low, while the soil erosion without area exclosure is high.

Figure 4.10 Partial view of a catchment with area exclosure in the study areas

Majority of the agricultural experts' and households (80 % and 68 %, respectively) revealed that the productivity of crops near area exclosure has been increased due to the low rate of erosion on those farmlands adjacent to the area exclosure (Table 4.8). Nevertheless, the remaining 8 % of the households showed that the crop production near the area exclosure was decreasing as area exclosure is the home of herbivores such as rabbit. But the other agricultural expert and households (20% and 24 % respectively) replayed that the existence of area exclosure has no change on value production.

Live stocks such as oxen, cows, sheep, goats, and poultry are the major types reared in the study area. They are "living bank" for the farmers. One of the sources of food for the livestock is grass from area exclosure. The access of fodder for livestock in the study area has been increased. In this regard, majority of the households and agricultural experts (76 % and 100 % respectively) believed that the access of fodder for livestock increased due to the exclosure. However, some households (12%) reflected that there has been a decrease in fodder because of the fact that they were not allowed sending their animals to the exclosures (Table 4.8).

4.3 Discussion

4.3.1 Land use land cover change

In agreement with Seto (2002), population increment desires a demand on land use land cover and affected on land cover. Worldwide, land cover today is changed primarily by direct human use: to farmland, rehabilitation, construction of settlement patterns and others (Meyer, 1995).The study also found a change in land use land cover in the different years of the study area. The settlement pattern from the year of 1984 to 2014was also increased due the increment of population. Similarly, the vegetation coverage from the year of 1995 to 21014 also increasing as rehabilitation goes up. Therefore from this finding it can be inferred that human interventions are the determinant factors for the changing land use and land cover.

4.3.2 Vegetation cover change

The magnitude of the NDVI is directly related to the photo synthetically active radiation. The calculated NDVI results in a value between -1 and +1. Less or no vegetation gives a value of 0 or close to 0 and high density of vegetation results in a value close to 1. The result of the finding in the vegetation coverage of the NDVI value is increasing from the year 1984 to 2014. The mean of NDVI value in the 1984 was 0.14 and in the 1995 was 0.20. But during 2000 the NDVI value decreased towards 0.16 and then increased to 0.20 in the year 2014. A critical look at the vegetation cover via the temporal scale revealed that there is considerable improvement of vegetation cover. Moreover, it is observed that we see dynamics towards the increasing trend due to the rehabilitation measures (Emiru, 2002).

An area exclosure is one of determinant factor for the increment of vegetation coverage and the NDVI value increased. Area exclosure on the study area plays a significant value in the vegetation cover change. Since the NDVI value ranges from -1 to +1, and then the result of the NDVI value in study is not nearest towards the value of +1. In agreement with Lillesand and Kiefer (2000), the result of the study shows that the area under discussion still needs a great integration in making and managing of area exclosure in better way. Moreover, planting of additional vegetation in the degraded areas and the whole Tabia in general is needed as a vital.

4.3.3 Comparison of Vegetation Coverage with and without Area Exclosure

Figure 4.11Partial view of vegetation status with area exclosure

Figure 4.12 Partial view of vegetation status without area exclosure

It clearly noted that there is contrasting comparison between Figure 4.10 or 4.11 and Figure 4.12. This indicates that coverage of vegetation within area exclosure is high as compared to areas without exclosure. For instance majority of the study areas without exclosure are used for grazing lands as observed from the practical view. In addition to this, the findings of the NDVI values of the vegetation cover with area exclosure and without exclosure as can be seen in Figure 4.9 in the two years also quite different. Comparatively speaking, the NDVI value without area exclosure is low.

4.3.4 Impacts of the Area Exclosure on the Livelihood of the Farmers

Therefore, the finding well communicates that the establishment of area exclosure on previously degraded hillsides, huge gullies and other wastelands has significant value on the vegetation coverage in the study area. This findings is cognizant with the studies of Abebe et al., (2006) showing that area exclosure brought degraded lands into productive landscape. Moreover, past work by Emiru (2002) shows that area exclosure improved the vegetation cover as compared to the implementation of area exclosure. Similarly, a comparative study between area exclosure and its adjacent open land shows that there was significant difference between the treated and untreated land use (Haile, 2012).

Area exclosure is a source of firewood for local farmers at harvested at regular. Particularly, harvesting dead branches and trees for domestic energy is practiced by the nearest dwellers around the area exclosure. Moreover, the farmers revealed area exclosure provide environmental services such as microclimatic regulation and soil conservation. From the finding of this study, area exclosure has a great contribution on production, erosion reduction, and fodder for livestock. Similarly to this finding Haile (2012) in Tigray, Halla exclosure also found the contribution of area exclosure has significant role on production and fodder.

CHAPTER FIVE

5. Conclusion and Recommendations

5.1 Conclusion

Land degradation is a major problem in northern highlands of Ethiopia. Consequently, the degraded lands were poor to offer landscape services for local farmers. However, the current study generated practical evidences, which shows the actual and potential role of area exclosure on the revival of vegetation cover and land rehabilitation on degraded lands of the study area. There was land use and land cover change in the last 30 years in the study area. As a result of area exclosures, vegetation covers are regenerating as confirmed by the NDVI values. Moreover, a comparison made between areas with area exclosures and without area exclosures found that vegetation cover was high and encouraging in areas with area exclosure.

The majorities of the local communities had developed a common sense of a positive attitude towards the issues of area exclosures due to their active participation on the management of area exclosure. Besides to the environmental rehabilitation, area exclosure enabled the local community to expand their source of income from increasing availability of fodder, firewood, crop production and other physical asset due to the increment of vegetation cover. Moreover, stabilization of large gullies around the area exclosure improved sustainability of farmlands to the local farmers. This indicates that there is good evidence on the fact that the communities around the exclosures have getting environmental and socio-economic benefit streams. Therefore, it can to conclude that area exclosure brought back the degraded landscape into productive area to ensure sustainable land management, which is a priority objective of our country and there by contribute to the achievement of Millennium Development Goals.

5.2 Recommendations

Depending on the findings of the study, the following recommendations are forwarded. From the point of findings, area exclosure is the vital for the overall improvement of vegetation cover. But still the rate of change and contribution of the area exclosure needs to be improved via collective action. It is also well noted that some respondents were not positive towards the implementation and expansion of the area exclosure. Therefore:

- In order to effective rehabilitation of degraded land, the Aexp of the Woreda and NGOs should strengthen the policies and technologies with the close involvement of local people.
- The regeneration of vegetation cover through area exclosure is not enough for improvement of vegetation covers in the study area. Thus, other continuous options like afforestation and reforestation activities should also be practiced to accelerate the improvement process by the Woreda Agricultural experts with full participation of the local people and with the integration of nongovernmental organizations and other concerned bodies is needed.
- After the degraded area is rehabilitated, the changes that occurred should be assessed and evaluated to ensure their sustainability for the future.
- The Agricultural experts should develop the community's capacity of area exclosure through sharing of experience with other areas to a better way of improving the vegetation coverage in the degraded lands.
- All in all, the findings are encouraging; therefore, area exclosure as land rehabilitation tool should be expanded to other similar degraded landscapes in Ethiopia and elsewhere in the world by considering the socio-economic aftermaths to the local communities.

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Appendices

Appendix I. Questions designed to collect data for the local people and Tabia administer

Mekelle University

Department of Geography and Environmental Studies

Post graduate program

Dear participant**,**

These interview questions are designed purely for academic purpose and to come up with appropriate recommendation to assess the aforementioned vegetation cover change. Your voluntary participation and truthful responses have great value, on the one hand, for the successful completion of my study and, on the other hand, for valuable recommendations for policy makers, to continue or amend the coverage at hand. In the study while only aggregate results will be used, your individual responses will be mentioned confidential.

Part I: Respondent's personal data

1. Age __________
2. Gender A) Male B) Female
3. Educational level a)illiterate b)Write and read only c)elementary d)secondary school
   E) 1st Degree F) if other please mentions ______________________________________
4. Marital status A) single B)Married C) divorced

1. When the area exclosure was established ________________________ E.c?
2. Who was the area exclosure established?
   A. Community B. Government C. NGO D. All
3. Who keeps the area exclosure?
   A. Committee B. Administrators C. Community D. All
4. What was the area before exclosure?
   A. Farm land B. Bare land C. Vegetation area D. Settlement E. All
5. What was the condition of your agricultural land before the establishment of area exclosure?
   A. Very bad B. Bad C. Moderate D. Good
6. Is there any change in vegetation cover after establishment of area exclosure?
   A. Increased B. decreased C. No change

7. The agricultural production near the area exclosure is:

A. Increasing B. Decreasing C. No change

8. What are the major methods of soil conserving in your locality?

A. Check dams B. Terracing C. A forestation and reforestation

D. Area closure E. If there any specify it ___________________________________

9. From where do you get fodder for your animals?

A. exclosure B. open field C. Crop residue

D. Others (specify) ____

10. What is your attitude towards area exclosure to the future?

A. Positive B. Negative

11. The effect of area exclosure on your farmland is:

A. Positive B. Negative C. No change

Thank you!

Appendix II: questionnaire designed to collect data from the agricultural experts

Mekelle University

Department of Geography and Environmental Studies

Post graduate program

Dear participant**,**

These questions are designed purely for academic purpose and to come up with appropriate recommendation to assess the aforementioned vegetation cover change. Your voluntary participation and truthful responses have great value, on the one hand, for the successful completion of my study and, on the other hand, for valuable recommendations for policy makers, to continue or amend the coverage at hand. In the study while only aggregate results will be used, your individual responses will be mentioned confidential.

Part II: Respondent's personal data

1. Age __________
2. Gender A) Male B) Female
3. Educational level a)illiterate b)Write and read only c)elementary d)secondary high school e)1st Degree F) If other please mention ____________________________________
4. Marital status A) single B)Married C) divorced

1. For what purpose the area was closed?

   A. To restrict from overgrazing B. To rehabilitate degraded area

   C. other (specify) ____

2. Why this Tabia is selected for area exclosure than from the other Tabias?

   ____

3. What was the area before exclosure?

   ____

4. Is there any change in vegetation cover after establishment of area exclosure?

   A. Increased B. No change

5. What are the major livelihoods of the farmers?

   ____

6. What is the impact of area exclosure on the livelihood of the farmers?

   A. positive B. Negative

7. What is the importance of area exclosure?

A. To increasing agricultural production   B. To decreasing soil erosion

C. If there any other specify it ____

8. The agricultural production near the area exclosure is:

A. Increasing   B. Decreasing   C. No change

9. Do you think that area exclosure is effective to rehabilitating the degraded lands?

A. Yes   B. No

10 What is the attitude of the society towards area exclosure to the future?

A. Positive   B. Negative

11. Were there obstacles during the establishment of area exclosure?

A. Yes, what are ____

B. No

12. What measures do you suggest for sustainability of land rehabilitation practices in the area? ____

Thank you!

Appendix III. Annual rain fall distribution of Koraro from 1997-2013

Month	Year																
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Feb	19.9	22	0	0	0	0	0	10	0	21	0	0	0	0	0	0	0
Ma	47.1	45	0	0	0	66.8	14.4	0	22	37	0	0	0	7.5	0	0	0
Apr	10.2	36.5	86	0	18.5	39.5	41.2	26	13.5	24	32.8	54.5	0	48.25	0	0	11
Ma	41.8	54.2	5	19.6	0	4	0	0	0	45	39	6.5	0	0	50	0	25
Jun	66.3	92.6	32	46	59	104.1	54.1	110	86	102	178.1	55	37	48.5	7	31	72.6
Jul	136.9	112.5	266.9	201.5	243	172.8	120	208	203	205.6	270	106.6	128.7	278	156	202	297
Au	130	64.9	187.4	208.5	314	279.5	94	173	157	208	170	106	159	293	111	155	198
Sep	0	0	0	0	0	0	0	0	0	0	0	0	0	33.5	0	147	0
Total	452.3	427.7	577.3	475.6	634.8	666.7	324.6	527	482	642.6	689.9	328.6	324.7	708.7	324	635	603.6
Mean	100.5	104.2	144.3	118.9	158.7	166.7	81	130.5	120.4	158	172.3	82.15	81.2	177.2	81	146.3	150.9